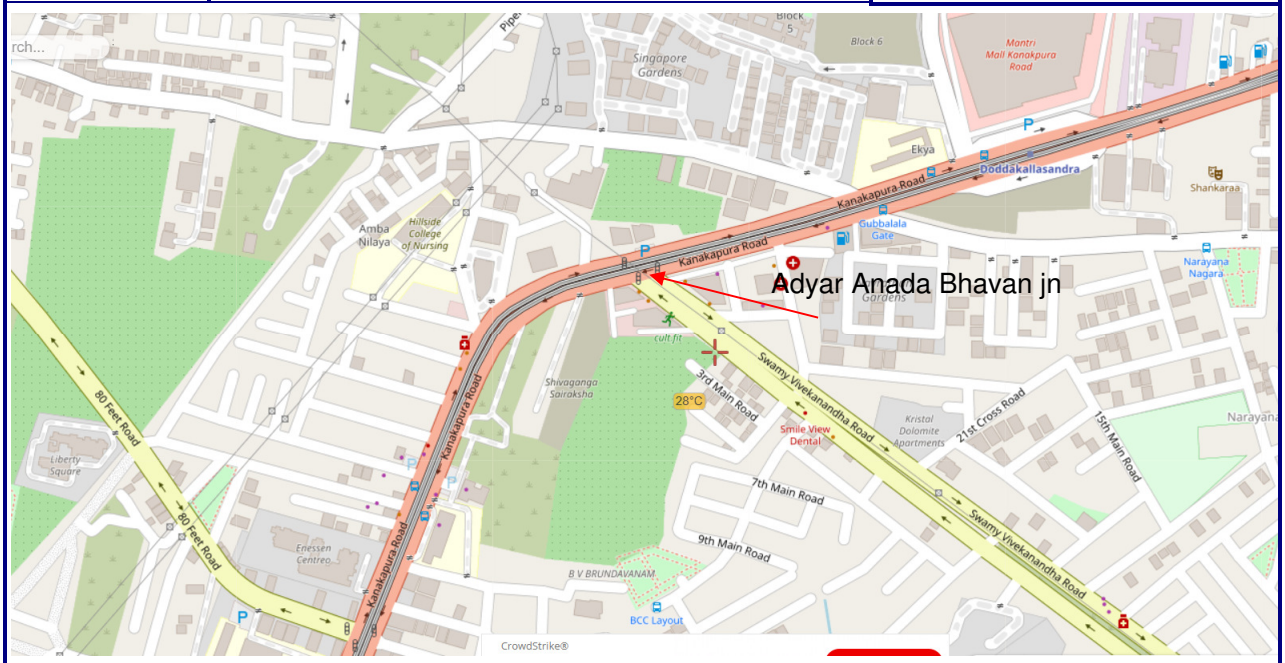
CLIENT	**Bengaluru Smart Infrastructure Limited (B-SMILE)** **#108,1st Floor, Annexe-2 Building** **N.R.Square,Bangalore**
PROJECT	Consultancy service for preparation of Detailed Project Report (DPR) for Construction of **Elevated Corridor (Flyover) at Adyar Ananda Bhavan Raghuvanahalli cross, Kanakapura Road.**
Title:	**DETAILED PROJECT REPORT (Volume-1)**
Doc No.	Report No. NC/B-SMILE/A2BDPR/01



DPR CONSULTANTS	**NAGESH CONSULTANTS** **Consulting Civil & Structural Engineers** **No-2, 6th Cross Ashokanagara, BSK 1st Stage, Bangalore – 560 050.** **Ph: 080-26617865.**

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2. Geotechnical Investigation Report

CHAPTER – 1- INTRODUCTION

CHAPTER -1 – INTRODUCTION

1.1 Back Ground.

Bangalore is one of the metropolitan cities in India and situated in the Southern part of the Karnataka state. The total extent of Bangalore metropolitan area (BMA) is 8005 Sq. km of which the main city compresses an area of about 741 Sq.km, the total population of Bengaluru is about 140.00 lakhs. Bangalore is located southern India 12°59′N 77°35′E longitude. Bangalore is "Silicon Valley of India" (or "IT capital of India") because of its role as the nation's leading information technology (IT) exporter A demographically diverse city, Bangalore is the second fastest-growing major metropolis in India.[20] Bengaluru has one of the most highly educated workforces in the world.[21] It is home to many educational and research institutions in India, such as Indian Institute of Science (IISc), Indian Institute of Management (Bangalore) (IIMB), International Institute of Information Technology, Bangalore (IIITB), National Institute of Fashion Technology, Bangalore, National Institute of Design, Bangalore (NID R&D Campus), National Law School of India University (NLSIU) and National Institute of Mental Health and Neurosciences (NIMHANS). Numerous state-owned aerospace and defense organizations, such as Bharat Electronics, Hindustan Aeronautics and National Aerospace Laboratories are located in the city, with its own well developed industries. The steady acceleration into the fast lanes of industrialization has come up rapidly.

Bangalore is rated to be one of the fastest growing cities in Asia. During the last couple of decades, the life style of people and their commutinghabits have undergone radical changes due to steep hike in

the cost of urban land inBangalore and the revolutionary changes in Automobile, Information Technology and BioTechnology Industries.

During this period the movement of people, from rural Karnataka and rest of the country, toBangalore has also increased considerably due to reasons such as:

- Better industrial climate in Bangalore
- Better employment opportunities
- Growth of other industries due to growth in IT sector

The prime drive of an urban economy is the Urban Transport infrastructure, facilities and services. Trade, industries and other economic activities thrive in areas where accessibility is good and mobility fast and smooth. Urban development takes place around such activity generators. Transportation is playing a vital role in the economic growth of the cities. It is able to make a substantial contribution to city efficiency when men and materialsare transported at minimal investment and operating costs. Thus, an able, adequate and efficient transport system enables cities to become catalysts for economic, social and administrative development.

In view of the above, there has been a steep increase in volume of vehicles on the city roads.The lack of need-based public transport system and the absence of any mass rapid transportsystem to commensurate with the development and increased vehicle population havefurther aggravated the problem. This is seriously being felt at the intersections andconsequently the intra-city commuting time has increased substantially, in addition toaccidents and pollution levels.

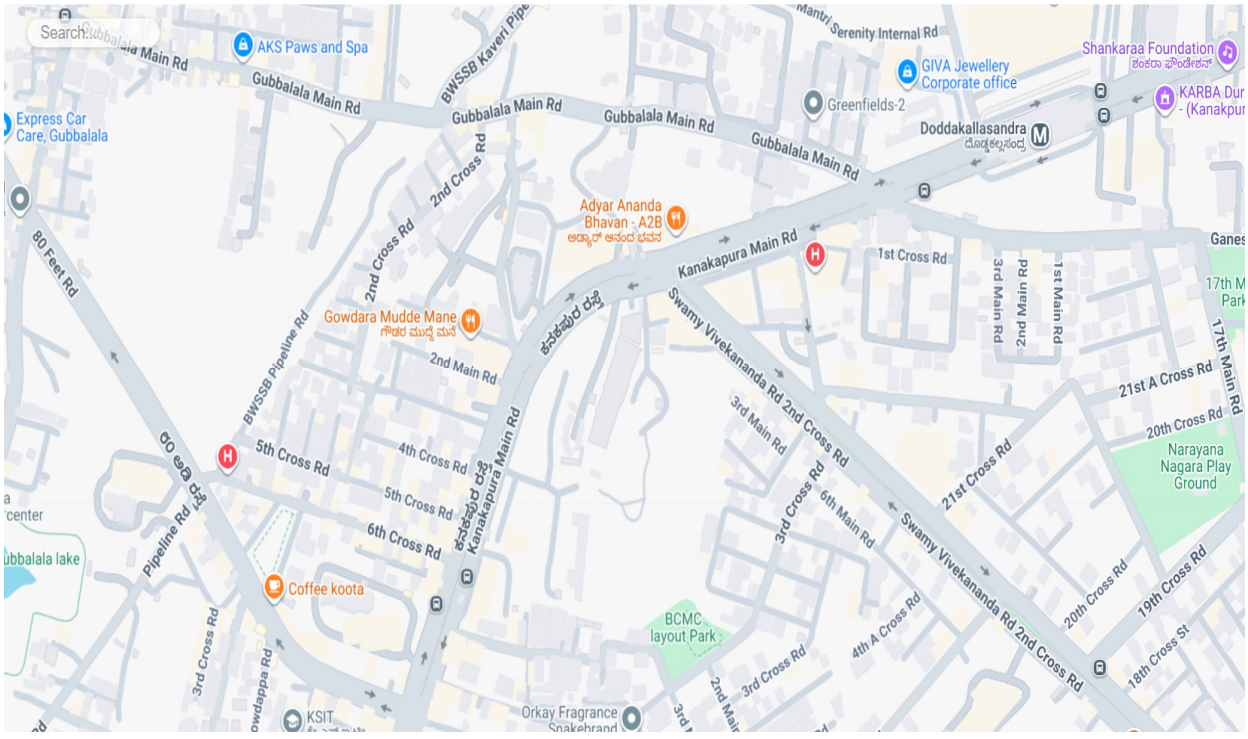
Hence, there is an urgent necessity to decongest the overcongested intersections.

1.2 Need for the Project:

B- SMILE, Bengaluru Smart Infrastructure Limited,a Special Purpose Vehicle **(SPV)** created by Karnataka government, **B- SMILE** responsible to oversee and implement major projects in Bengaluru.As a comprehensive solution for **End to End traffic solution** to the city of Bangalore the **B- SMILE**is planning for 120 km of elevated roads in the various part of the city to provide End to end solutions.

The project under consideration is –

Proposed Elevated Corridor(Flyover) at Adyar Ananda Bhavan Raghuvanahalli cross, Kanakapura Road(Lat: 12°52'59.8" N Long: 77°32'54.95" E)



A2B junction is junction at the Kanakapura road and road going towards Anjanapura BDA lay out. The junction is at east side of Bangalore-Kanakapura road. Through traffic along Kanakapura road and right turning traffic from and towards Anjanapura road is creating a bottle neck at junction resulting in congestion of vehicles and long waiting time at the junction requiring the solution.

To arrive at better picture about the present situation following studies are conducted –

- Topographical Survey
- Traffic Studies.
- Geo Technical Investigations.

This report presents above studies, detailed specifications, Bill of quantities, estimates and recommendations to decongest the surface level traffic and improved travelling conditions for traffic along Kanakapura road.

CHAPTER – 2 – OBJECTIVE AND SCOPE OF STUDY

Chapter – 2 – OBJECTIVE AND SCOPE OF STUDY

2.1. Objective

The tender for Detailed Project Report for Proposed construction of Elevated Corridor (Flyover) at Adyar Ananda Bhavan Raghuvanahalli cross, Kanakapura Road

Is awarded by **B-SMILE to the M/s Nagesh Consultants**, Bangalore through competitive bidding.

The alignment and carriage width finalised in the concept stage is considered for thefollowing primary objectives of the study –

- To conduct investigations to study the approved alignment, for improvement of traffic movement along the proposed corridor.
- Suggest on optional and Feasible Structural System.
- Improve the existing junction to streamline traffic flow at grade level.
- Prepare cost estimate and bidding documents.

2.2 Project Scope:

The scope of the consultancy study involves the following -

a) Preparation of detailed project report (DPR) including detailed cost estimate.
b) The Detailed Project Report (DPR) would include detailed alignment design, design of gradeseparated structures, design of service roads, pavement design, and quantities for civil construction items, cost for civil construction estimates as per Schedule of Rates and preparation of documents required for tendering.

c) The Consultant shall follow relevant latest IRC publication and other circular on policy matters - Quality assurances manual. Layout and GADs are to be submitted for the structures including their approaches.
d) Consultant shall prepare necessary technical document for submitting to all stake holders/department through B-SMILE for getting their inputs / approval.
e) Liaisoning with stake holders / department for identification of their utilities, assets and mapping of utility and assets falling in the project corridor.
f) Conducting Detailed Topographical survey and preparation and submission of final Auto CAD formatDrawing.
g) Geotechnical investigation and submission of report.
h) Traffic Survey.
i) Liaising with Revenue Department officials for collection of revenue records required for landacquisition/TDR.
j) Preparation of Auto CAD drawing showing Existing Right of Way (EROW) / Proposed Right of Way (PROW).
k) Preparation of Land Acquisition Plan and Schedule and Assisting B-SMILE for Preparation of Form-1 notification for TDR.
l) Preparation of 3D model and Walkthrough of Proposed elevated corridors.

Further, co-ordinating with various agencies involved in easing traffic in the city and suburban area of Bangalore City such as, Elevated Corridor, Metro Rail Project and their extension up to and into the Junctions under study will also be studied and factored-in while finalizing the proposals.

2.3 Approach Methodology:

2.3.1 Stage - I Field Investigation:

- Conducting Topo Survey.
- Soil Investigation as per NIT.
- Conducting Traffic Survey as per NIT
- Identifying the utilities.

2.3.2 Stage - II Analysis and Design required for preparation of necessary drawings for EPC Contract

- Soil investigation report as per field and lab tests.
- Preparation of GAD and discussing with the authorities for approval of the same.
- Detailed Analysis of typical Super Structure and typical sub structures.
- Preparation of Typical cross sections of Super structure and sub structure for tender purpose
- Environmental impact analysis.
- Preparation of detailed BOQ and cost estimates along with rate analysis.
- Preparation of Tender documents.

2.4 Design Philosophy.

The Technical proposal given in this Report consists of Designs, Drawings and all Technical Details based on Surveys and Investigations stated in Section 2.2 above. The Design standards adopted in the present Design are in accordance with the codal provisions of India as stipulated by the Indian Roads Congress (IRC), Indian Standards Specification (IS) and the Ministry of Road Transport & Highways. Deviations may be considered in planning parameters if extremely necessary considering the dense urban conditions, like the present one, from the present codal provisions. These modifications in the design will be adopted based any recognised international codes, such as Euro code, BS codes, ACI, DIN, French codes and/or on similar projects at urban locations as "Good Engineering Practice".

The Designs and Drawings presented as a part of this report are based on the Studies, Investigations and Designs which provide a fair basis for making Detailed Designs and Drawings subsequently. The consultants opine that the detailed engineering designs and drawings shall be prepared on the basis of this report before construction, based on actual details at site viz., utilities, Geo Technical data and Soil profile etc. by the project implementing agency.

2.5 Deliverables:

Following are proposed to be submitted as part of the Detailed Project Report -

a) Main report

- Executive summary.
- Introduction.
- Traffic surveys including traffic forecast.
- Engineering surveys and investigations and proposed road features
- Design standards and specifications
- Drainage facilities including cross drainage structures
- Environmental and social issues / considerations and proposed rehabilitation and resettlement measures
- Material, labour and equipment
- Design details of various components.
- Rates and cost estimates inclusive of land acquisition cost.
- Construction program and constraints.
- Traffic management and safety measures during construction.
- Shifting of utility lines and cost.
- Plan of action for Traffic diversion and roll of Traffic police.
- Miscellaneous.
- Conclusions and recommendations.
- The design calculations etc,

b) Cost Estimate

c) Drawings

d) Tender Document

CHAPTER – 3 – PROJECT COSTING

Chapter – 3 – PROJECT COSTING

3.1. General

The project cost has been estimated mainly based on the rates derived after rate analysis using Schedule of Rates of Uni SR 2023-24 Karnataka Public Works Department, supplemented by issue price list issued by the Superintending Engineer PWD (Bangalore Circle) dated: 08.10.2025. For the few items not covered in the above SR, rates from NH SR / market rates have been adopted. The Data rate for UHPFRC, which is not in SR has been workout and presented in Annexure below.

The detailed estimate is enclosed as Appendix -1. At the end of the report. The bill wise cost summary for the project is shown in below for Proposed

Elevated Corridor (Flyover) at Adyar Ananda Bhavan Raghuvanahalli cross, Kanakapura Road

3.2.**COST SUMMARY**

Sl. No.	Items	Amount (In Rs)
1	Site clearance and dismantling	691,257.00
2	Compound wall construction	4,833,809.00
3	Flyover works (via duct portion)	275,758,513.75
4	Flyover approach works	49,810,241.28
5	Diversion road (maintenance work during construction)	3,853,146.31
6	Drain/footpath	15,149,962.00
7	Surface level road /slip roads (post construction)	36,593,875.60
8	Road furniture & other work	2,104,512.00
9	Overhead gantry	2,016,444.00
10	Pier protection below flyover	5,793,362.00
11	Height gauge	563,873.00
12	Electrical works	5,108,302.00
13	Preliminary works and Design Charges	3,557,409.00
	Amount put to tender (APT), Rs.	**405,834,706.93**
	GST @ 18%	73,050,247.25
	Total Civil Cost, Rs.	**478,884,954.18**
i	Provision for Contingencies and Provision for Departmental Establishment Charges @ 2% on APT	8,116,694.14
ii	Provision for Independent Engineer / PMC @ 1.50% on APT (Including GST)	6,087,520.60
iii	Provision for Price escalation @ 5.0% for the 2nd year i.e., 0.5% of APT (Including GST)	10,145,867.67
iv	Provision or utility shifting @ 8.5% of Project cost (APT) (Including GST)	34,495,950.09
v	Provision for Arboriculture/ Afforestation @ 0.50% on APT (Including GST)	2,029,173.53
vi	Land Acquisition Cost including Structures	1,751,089,340.00
vii	Miscellenous and other Department Deposits	9,150,499.78
	Total Project Cost	**2,300,000,000.00**

Rupees Two Hundred and Thirty Crore.

3.3. LAND ACQUISITION:

To execute the work, it is required land and structure acquisition and cost of Rs. 175.10 Crores.

3.4. MATERIAL RATES

The Original basic price (Ex-Factory) of cement, steel and bulk bitumen exclusive of all taxes and duties considered are as per Uni SR 2023-24. The difference in rates will be added to/subtracted from the basic rates in the SR.

CHAPTER – 4 – FIELD SURVEYS AND INVESTIGATION

Chapter – 4 – FIELD SURVEYS AND INVESTIGATION

4.1. General

In order to arrive at a feasible traffic improvement measure at ProposedElevated Corridor (Flyover) at Adyar Ananda Bhavan Raghuvanahalli cross, Kanakapura Road

various field surveys and investigations were conducted in month of May 2025.

The Study and Investigations were in accordance with the Scope of Work entrusted to the Consultants. They include:

- Field Reconnaissance
- Traffic Surveys
- Topography Surveys
- Soil Investigations / Borehole Investigations.

4.2. Site Appreciation

The proposed corridor plays a crucial role in channelizing traffic movement from Banashankari towards the southern part of Bengaluru, covering major areas such as Banashakari BDA Layouts, Kanakapura, Anjanapura, and JP Nagar.

At present, the existing traffic flow along this stretch is heavily congested and. This leads to frequent bottlenecks, reduced travel speed, and increased travel time, particularly during peak hours. The project site thus lies in a high-demand traffic corridor with continuous vehicular

movement, indicating the necessity of capacity augmentation and improved connectivity.

4.2.1. Type of Junctions

Name of Junction	**Type of Junction**
A2B Junction	3-Legged junction

4.2.2 ROW and Gradient of Existing Roads along the Stretch

Name of Road	**Gradient**	**ROW**
A2B Junction	flat in nature	25.3m to 46.5m

A2B JUNCTION

Towards Vajarahalii

Towards Doddakalsandra

Towards Anjanapura

4.2.4 Major Utilities along the corridor: -

- BMRCL metro line function at median along Kanakapura Road and having Metro Station adjacent to Konanakunte Junction.
- High tension electrical lines crossing the junction.

4.3. Reconnaissance Survey

A reconnaissance survey was carried out along the project road to appreciate them and to finalize the locations of the field surveys and investigations. The project appreciation of the project road was presented in the Inception Report submitted. The existing condition and features of the project road is discussed in this section.

The Consultant's team members with Key professionals have inspected the site on june 8th 2025 to familiarize themselves with the site conditions and gather necessary field information and for planning various investigation activities to be performed for preparing various reports. This includes activities like Road Inventory, Existing pavement conditions, possible re-alignments where the existing road geometry are inadequate. The specific observations made by the team members belonging to Highway, Geo technical and materials, Pavement, Surveying, bridge group, social and environmental group and Traffic were presented in the Inception Report.

The team continued with additional field visits and collected data from BBMP / BWSSB / BESCOM / KPTCL / BSNL other agencies. The data being gathered include right of way details, land records, road

construction history, available material sources, planned improvements on the project road like ramps, re-alignments, development plans in the project corridor. During the field reconnaissance survey, stretches requiring realignment have been identified.

- Presently Green Line Metro functioning at median.
- The Traffic at Junction is controlled by Automated Signals.

4.4 TOPOGRAPHICAL SURVEY: -

Topographical survey was conducted establishing control points along the corridor using DGPS for X, Y coordinates and Z coordinate is established with respect to MSL from the known point of elevation.

Site features as been captured using total station and levelling data was collected using auto level.

The following features were collected during survey:

- Existing road pavement surface, its variation in width along with all other relevant road.
- details like centreline of carriageway, pavement edge, embankment/cutting edges top
- and bottom, side drains, signs, km posts etc.
- Location of traffic islands, median, police chowks, within limits of ROW.
- All religious places – churches, Towers, Parks, and Heritage Buildings etc., including
- location, building lines and clear dimensions of compound walls and extensions.
- Trees (position, species and girth measured 1.2m from ground level) Tree Species and

- type of crops.
- Building fronts and outlines (to be classified by construction type i.e., RCC/tiled
- house/thatched house etc with number of storey).
- Electric transformers, mast, tower, etc.
- All telephone lines. OFC lines, Private OFC lines, Water Pipes including manholes abovethe ground belonging to layouts/ colonies/nagars and other bodies, electricity lines etc.

Levels along the alignment were taken at every 20m intervals and at all intermediate breaksalong the centre line of the existing alignment. Spot levels were recorded at critical pointssuch as horizontal curve start, centre and end points and vertical curve start, centre and endpoints.
Cross sections, covering drain to drain on either side of service road or compound to compound or building line which ever was more, were taken at intervals of 20 m in general with levels at 5m c/c. Cross sections were taken at the centre line of all culverts and at all critical points, mentioned earlier.

Details of the topographical survey are shown in drawing NC/B-SMILE//TOPO-01 which is enclosed along with drawings volume.

4.5 TRAFFIC SURVEY

4.5.1. Project Background

Traffic studies are the initial step of any road project whether it is improvement/upgradation over existing road. This generally considered by way augmentation of existing capacity of road such that, the road would handle the present and future traffic in acceptable level of service. In order to decide upon the type of improvement or upgradation required needs some base line studies related to traffic volume and its composition. These traffic studies are the base for deciding many components such as roadway width, lane width, pavement design etc. All these signify the importance of traffic data. Traffic flow on rural section is different when it is compared with that of an urban road section. In the urban areas, the traffic flow is frequently interrupted with close intersections and continuous ribbon development. When there is a ribbon development is majorly a commercial establishment, this will also affect the through traffic along the corridor due to parking or stopping near commercial establishment. All these conditions warrant for congestion and delay in the traffic flow thereby increase in the travel time leading to unnecessary increase in Vehicle Operation Cost. Presently, the study is under consideration is pertaining to an urban section of an important arterial road in the Bangalore City which has similar type of ground condition and carry maximum volume of passenger vehicles specially Two-Wheelers, Autos and Cars.

The proposed project road forms a critical link within the southern part of Bengaluru city. It covers a stretch of –

ProposedElevated Corridor (Flyover) at Adyar Ananda Bhavan Raghuvanahalli cross, Kanakapura Road.

The traffic study for the project consists of studying the traffic along existing road of Kanakapura for Flyover at junction of A2B to ease out the traffic congestion at junction by constructing flyovers.

4.5.2 TRAFFIC SURVEY LOCATIONS

The following survey locations were selected for the traffic surveys, and the schedule of traffic surveys is presented below. The following **Table 1.1** gives details of various traffic surveys conducted with period of survey.

Table 1.1 Schedule of Traffic Surveys

Sl. No.	Type of Survey	Duration	Location	Date(s) of Survey
1	Turning Movement Surveys	24 Hrs	Adyar Aanand Bhavan Junction	02.04.2025

4.5.3. Purpose of Traffic Study

Traffic surveys have been carried out on the project corridor in order to identify present and likely future scenarios so as to device suitable remedial measures and to evolve appropriate design method. The primary objectives of these traffic surveys are to determine the characteristics of traffic movement on the project corridor determine the turning movement pattern of traffic at road intersections.

As per the present traffic flow pattern following have been observed;

- From all Junction the traffic is allowed in both directions.
- The traffic flow has been restricted in many directions due high volume of traffic flow. The details of traffic flow are presented in subsequent sections.

4.5.4. Summary of Peak Hour Traffic at Various Junctions along Kanakapura Road

SL No	Junction	Total	Years										
			2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	A2B Junction	VEH	7539	8062	8622	9220	9860	10545	**11277**	12059	12896	13791	14749
		PCU	6739	7207	7707	8242	8814	9426	**10080**	10780	11528	12329	13184

As per clause 5.10.4 of IRC: SP: 90-2010 and as per clause 4.5.6 of IRC: 92-2017, Grade Separators or Interchanges, in general, are expensive to construct and a major factor influencing the cost is the type of arrangement made for the various traffic movement.

The arrangement may range from separating only one traffic movement from other to the complete separation of each traffic movement from every other movement, so that only merging and diverging movements remain. Similarly, the vehicle operating cost will vary depending on the type of ramp arrangement, from direct conflict-free connections to indirect connections involving extra travel distance. However, the following points may be helpful in guiding the choice of an interchange at the preliminary planning stage:

1. Interchanges will be required at all major crossings on highways developed to expressway standards.
2. An interchange may be justified at the crossing of a major arterial road with another road of similar category carrying heavy traffic.
3. An interchange may be justified when an at grade intersection fails to handle the volume of traffic resulting in serious congestion and frequent choking of the inter-section. This situation may arise when the total traffic of all the arms of the intersection is in excess of 10,000 PCU's per hour.

4. High and disproportionate rate of fatal and major accidents at an interaction not found to respond to other traffic control or improvement measure may warrant an interchange.
5. In some situations, the topography is such that interchanges are the only type that can be constructed economically.
6. The requirement of interchange may also be justified from the existing constraints of the junctions other than traffic volume like parking, market, important and religious structures, buildings with frequent crowding.
7. While planning interchange at a particular location the traffic requirements of the entire road on both sides should be taken into account.

As per the above traffic data, the traffic at junction exceeded the capacity which warrants for grade separator facility or will exceed within the next 5 years and become bottleneck in near future. This indicates the requirement of alternative solutions to overcome this problem in terms of grade separators, development of alternative routes.

Detailed Traffic report is appended in Annexure-1

4.6. Soil Investigation

Geo - technical investigations were carried out along the corridor to understand the soil strata through exploratory borings.

Following guidelines used to carry out geo tech investigation-

- IS: 1892 – 1979: CODE OF PRACTICE FOR SUB-SURFACE INVESTIGATION FOR FOUNDATIONS, and
- The specifications given in Clause 1102.1 of SPECIFICATIONS FOR ROAD AND BRIDGE WORKS (Fifth Edition)

Summary and Recommendation are presented below –

- Given the heavy superstructure loads anticipated, deep foundations are recommended. Bored cast-in-situ reinforced concrete piles of 1.35 m diameter shall be adopted in accordance with IS 2911 (Part 1/Sec 2) and IRC:78/IRC:112, using site-specific geotechnical data and confirmed groundwater conditions.
- Each pile shall be founded in rock with the following socketing requirements, whichever is met earlier: (i) socket ≥ 3D(≈ 4.05 m) into dense weathered rock/refusal stratum with SPT-N > 100, or (ii) socket ≥ 1D (≈ 1.35 m) into hard rock with core recovery CR > 30%. The target average pile length is 15 m, subject to confirmation during construction by drilling logs and on-site test results.
- Ultimate axial and lateral capacities shall be evaluated using appropriate rock socket parameters (end bearing and side shear) derived from site investigation and, where feasible, instrumented load tests. Adopt factors of safety as per IS 2911/IRC depending

on test evidence (typically FOS 2.5 for axial compression from static tests, higher if inferred)

The details of soil investigations are enclosed as **Annexure-2.**

4.7. Roadside Investigations

Preparation of road inventory of the project road was undertaken first. The purpose of the survey was to obtain the necessary information regarding the road features along the project road, condition and performance of drainage structures and other ancillary road features like footpath, median, kerbs etc. An integrated program to carry out surveys and investigations were developed, using IRC SP -19 as a general guide.

The following information was collected as part of the survey

- Carriageway width
- Shoulder widths
- Surface type for carriageway and shoulders
- Embankment or cut and approximate height
- Location, type and condition of side drains
- Location and type of road access and roadside features (parking bays, bus stops, and all major and minor commercial establishments)
- Roadside land use (agriculture, barren, built-up. slum areas, urban)
- Presence of crossing traffic (vehicular, pedestrian).

CHAPTER – 6 – PLANNING AND DESIGN CRITERIA

Chapter – 6– PLANNING AND DESIGN CRITERIA

6.1. Planning Grade Separator /Elevated corridors

One or combination of the following usually guides planning of grade separator in urban areas:

- Elimination of conflicting traffic streams of traffic
- Hierarchy of the intersecting roads
- Intersection traffic characteristics
- Present development level and proposed development pattern for the influence area
- Lack of alternative routes / modes
- Feasibility with respect to available space and minimum land acquisition
- Utilities present at the project location, feasibility of shifting / relocation
- Other major infrastructure projects planned
- Cost and Economic considerations
- Traffic diversions and management during construction

6.2. Planning Criteria

The following paragraphs briefly highlight the various Design considerations and standards used for the present proposal. However, it is important that the preamble to Design criteria is clearly understood in the context of urban development –especially with due consideration to traffic, existing road network, development pattern, right of way, rise and fall of road etc.

The Indian Roads Congress and the Ministry of Surface Transport and Highways specify various guidelines and specifications for flyovers, junctions and other facilities pertaining to flyovers. These specifications are largely based on the theoretical considerations and ideal situations which can hardly be obtained in urban situation for a city like the present one. Hence, in the present proposal, certain changes and modifications in the Design standards are reviewed keeping in view the site constraints.

6.3. Design Standards - Roads

Design standards for the Design of Horizontal and Vertical Geometry and other road elements are used referring following guidelines of Indian Roads Congress:

Design standards considered are briefly stated below.

6.4. Geometry

The horizontal geometry will be designed in accordance with Clause 10 of IRC:86-2018. Following considerations are made in horizontal geometry design

- Minimum disturbance to existing structures which are already constructed based on inputs from B SMILE in various meetings / discussions.
- To maintain existing road horizontal profile to the extent possible.
- Road widening considering building lines on either side of existing carriageway.
- Rise and fall of existing road in design of the facility;

6.5. Design Speed

The design speed for elevated road/grade separator in urban stretch is generally governed by the existing road plan and building lines. The most critical sections governing the design speed is the turning movement of vehicles on curves and available sight distance to traffic approaching the junction. Considering above factors, design speed of 60 Kmph is adopted in general, except at sharp turnings and at exceptional locations where site constrains, minimum speed of 30 Kmph is followed.

These constrained locations are considered in alignment design considering ground constraints like building lines, land acquisition and utilities.

6.6. Horizontal Alignment

Horizontal alignment for the grade separator is designed in accordance with IRC:38-1988 "Guidelines of Design of Horizontal Curves for Highways and Design Tables". Clause 10.3 of IRC:86-2018 specifies minimum curve radius of horizontal curve for 60 Kmph as 70m for 4% super-elevation. These guidelines will be followed for reasonably flat and less winding alignments. Depending on site constraints modifications are made for providing tighter curve radius wherever required based on site specific considerations. For ramps, curve radius corresponding to 20 Kmph design speed is proposed.

6.7. Super Elevation on Curves

Super-elevation on horizontal curves will be attained as per IRC: 38-1988. The super elevation will be limited to 4 % as per Cl 10.2 of IRC:86-2018 as the project area is in urban section.

6.8. Cross-Sectional Elements of Grade Separator

Width of grade separator has a direct relationship with the traffic volume it is expected to serve and width available at ground level based on land acquisition. Widths of flyovers / grade separator for various categories are as shown in Table 6-1.

Table 5.9.1 Cross Sectional Elements of Deck

Lane Type	Carriageway Width	Kerb & Crash Barrier	Total Width (m)
Main Flyover 2-Lane Unidirectional	7.5 m	0.5m x 2 sides	8.5m
Exit Ramp – 2lane Unidirectional	7.5 m	0.5m x 2 sides	8.5m

6.9. Surface Level Road

The surface level road will carry local remaining traffic (traffic using shops and commercial establishment, crossroad). The width of surface level road will depend on the traffic at the surface level after the flyover is constructed and majorly on space availability in urban roads. approaches to fly over is mostly at the footpath locations or existing service road with land acquisition and existing traffic pattern at grade will not be altered. A minimum of 5.5m carriageway at surface level along with 1.5m Drain cum footpath is maintained at all locations.

6.10. Cross Slope

The deck and approaches are proposed with 2.5% cross slope.

6.11. Vertical Alignment

The vertical geometry of the flyover is designed as per guidelines given in IRC: 92-1985. Clause 5.1.2 of IRC: 92-1985 states that the vertical gradient should be desirably kept at 4%, but in no case exceed 6%. Vertical curves are provided at locations of change in gradient. The length of vertical curves is dependent on change in grade between two vertical straight and this will be as per IRC SP: 23-1993 "Vertical Curves for Highways".

6.12. Approach Ramp

It is proposed to adopt "Reinforced Earth" type retaining structure for the approach ramp. The reinforced earth facia wall made of precast concrete panels offers great scope for a variety of aesthetic treatments in the form of panel shapes and colour. Apart from aesthetics, it improves the speed of construction.

Approach gradient of grade separator is primarily dictated by the following.

- Space available in the approach road
- Distance available to nearest major intersection.
- Access for cross roads, bus stops or other important buildings.

Clause 11 of IRC: 86-2018 specifies that the maximum vertical grade in urban area should be limited to 1 in 25. Approach longitudinal gradient of 1 in 30 will generally be attempted for surface level roads to account for the mixed form of traffic present in the city. However, considering the project location, type of vehicles (Majority of 2 Wheelers and 4 Wheelers) ramp of 1 in 20 is proposed as per the discussion with B SMILE to minimise the cost of construction and cost of land acquisition

However, in situations, where the ramp length needs to be curtailed due to proximity of adjacent intersection or similar cases, the slope might require to be restricted.

6.13. Design loads For Structure

- **Dead Loads**

Self-weight = 25 kN/m^3

Crash Barrier = 7.75 kN/m

Wearing Coat = 2 kN/m^2

- **Vehicular Live loads**

The design is carried out for IRC vehicular live loads as per IRC 6:2017 corresponding to various traffic lanes i.e 2 Lane (7.5m carriageway).

Impact factor considered as per IRC-6-2017, corresponding to Class A& Class 70R Vehicle.

- **Wind forces**

Wind forces have been considered as per IRC: 6 – 2017 and subsequent amendments in the latest edition of Indian Highways.

The appropriate wind force on Superstructure and substructure are considered as per CL 209 IRC 6 : 2017 with a basic wind speed of 33m/s corresponding to Bangalore location.

- **Seismic force**

The structure has been designed for the seismic force as per the provisions of IRC-6-2017, corresponding to seismic zone – 2.

- **Temperature range**

i) Fordesign of structure to account for temperature in formula, (ΔL) = α Lt,

The value of T shall be (+/-) 29.55/25.55 degree centigrade.

Where α= Coefficient of expansion or contraction = 1.2×10^{-5}

L = Length of the member

(ΔL) =Expansion / Contraction due to temperature variation in appropriate units.

ii) The super-structure is also designed for effects of distribution of temperature across the deck depth.

- **Vehicle Collision Load:**

It is proposed to provide suitable fencing system taking in to account its flexibility having a minimum height of 1.50m above the grade level carriage way and according the piers are designed for residual load component, with vehicles plying with speed limit of 30 Kmph as the road at grade are city roads, as per art 225.3.1, IRC: 6-2017.

- **Braking Force**

Braking Force is considered as per CL 211.2, IRC:6-2017. The horizontal load will be fraction of vertical reactions as per the guide lines of CL 211.2.

- **Friction Force**

Friction force is considered as per CL 211.50 IRC: 6 -2017

- **Centrifugal Force**

Centrifugal force will be as per CL 212 IRC: 6 -2017

- **Active Earth Pressure**

Active Earth Pressure will be as per CL 214.1.1 IRC: 6 -2017

- **Live Load Surcharge**

Live Load Surcharge will be as per CL 214.1.1.3 IRC: 6 -2017

6.14. Design Basis – Structure

6.15.

6.15.1. Super Structure.

SL NO	DETAIL	DESCRIPTION
General Arrangements		
1.	Span Arrangement	45.0m for standard viaduct spans is chosen for the corridor in view of the following point- 1. Depth of Super structure will be more for long spans, which will affect the aesthetics in urban condition.
2	Expansion Joints	Expansion joints are proposed at each span.
2.	Carriage way	2 lane Unidirectional flyovers are proposed for each direction.
3.	Crash Barrier / Median	RCC Crash Barrier on both sides
4.	Overall width of deck.	8.50m wide.
5.	Type of superstructure.	**UHPFRC Box Girder.**
6.	Overall depth of superstructure.	2.4m depth.
7.	Minimum thickness of deck slab.	250mm.
8.	Cross Drainage	2.5% camber in straight with drainage spouts at the end of carriageway with down take pipes to convey the way to grade level

		drains.
9.	Wearing Coat	Bituminous Concrete uniform thickness 50mm in single layer on 4mm thick mastic pad.
10.	Noise Barrier	Noise Barriers proposed for the project road for site face properties.
Loads considered in designs.		
1.	Dead Load	25 kN/m^3 for RCC 22kN/m^3 for asphaltic wearing coat.
2.	Superstructure live load.	Superstructure designed for IRC:70R & Class 'A' Vehicle
3.	Load combination	DL + SDL + VhLL.

Material adopted.		
		Steel – Fe550 for all structures Low Relaxation Class 2 Strands are proposed For Pre-stress steel <u>Superstructure</u> <u>For Main arm, Entry and Exit Ramps</u> **UHPFRC –M150 forU-Trough** HPC M50 for deck slab and end diaphragm <u>Substructure</u>

		M50 for Pier and Pier Cap M35 for Pile and Pile Cap Crash Barriers are in M40 Grade Concrete.
Permissible stresses:		
1	In Concrete – Flexural	IRC 112-2020 (CL 12.2)
2	Permissible Tensile stresses in case of PSC	As per IRC112-2020 (CL 12.1) at locations other than segment joints
	Under Transfer Condition	
	Under Service Condition, with Frequent Combination As per Table B.3 of IRC 6-2017 (column 3)	As per IRC SP 65 - 2018 (CL 3.2) at segment joints
	Under Service Condition with Rare Combination As per Table B.3 of IRC 6-2017 (column 2)	As per IRC SP 65 - 2018 (CL 3.2) at segment joints
3	Crack Width	As per IRC: 112-2020 (Cl:12.3.4)
4	Flexural Tension	As per Table 6.5 IRC 112-2020
5	Modulus of Elasticity, Ec	As per Table 6.5 IRC 112-2020
6	Permissible Direct	As per IRC-112 (Cl:12.2.1)

	Compressive Stress	
7	Maximum permissible shear stress	As per IRC-112 - 2020(Cl:10.3.2 and 10.3.3)
8	Permissible shear stress without shear reinforcement.	As per IRC-112 - 2020 (Cl:10.3.2)
9	Elastic Modulas of Steel	As per IRC-112 - 2020 (Cl:6.2.2)
F	Structural Design	
1	Design will be carried out by limit state method as per IRC-112	
G	**Expansion joint:**	
I	Slab Seal type as per MOST/IRC specifications, also conforming to recent amendments of MoSRT&H, Transport Bhawan, New Delhi.	
H	**Bearing Data**	
I	Type of bearing	POT Cum PTFE/Spherical bearings conforming to IRC 83: (part III/IV), also conforming to recent amendments of MoSRT&H, Transport Bhawan, New Delhi.
I	**General Design Requirements Provided**	
1	Minimum clear cover for any reinforcement	40mm for super structure 75mm for foundation
	Concrete Cover to Post tensioned ducts	75mm
2	Minimum tensile reinforcement in beams	As per IRC:112-2020 (Cl:16.5.1.1)
3	Minimum shear reinforcement	As per IRC-112 - 2020 (Cl:16.5.2)

4	Minimum and Maximum reinforcement bar sizes	As per IRC-112 - 2020 (Cl:15.5.2.2)
5	Reinforcement bar spacing	As per IRC-112 - 2020 (Cl:15.2.1)

6.15.2. Substructure.

Substructure system.		
Load considered in design.		
1.	Dead loads from superstructure – (G1)	
2.	Superstructure imposed loads from superstructure – (G2)	
3.	Vehicular live load from superstructure – (G3).	
4.	Self Wt of pier system – (G4)	
5.	Braking load from vehicular traffic – (fb)	
6.	Wind loads	As per IRC – 6-2017 for wind speed of 33m /sec.
7.	Seismic effects	FeQ. Zone factor – 0.10 Damping – 5%. Importance factor – 1.2.

6.15.3. Foundation.

SL NO.	DETAILS	DESCRIPTION
Foundation system.		Pile Foundation with Bored Cast in situ Piles as per relevant Codal Practice
Loads considered in design		
1.	Dead loads from superstructure – (G1)	
2.	Superstructure imposed loads from superstructure – (G2)	
3.	Vehicular live load from superstructure – (G3).	
4.	Self Wt of pier system – (G4)	
5.	Self Wt of foundation - (G5)	
6.	Braking load from vehicular traffic – (fb)	
7.	Wind loads	As per IRC – 6-2017 for wind speed of 33m /sec.
8.	Seismic effects	FeQ. Zone factor – 0.10 Damping – 2%.

		Importance factor – 1.2.
material adopted		M50, M35 grade of concrete, Fe550 grade steel&Low Relaxation Class 2 Strands are proposed For Pre-stress steel
Limiting stresses		
1.	In concrete flexural compression.	16.8 Mpa for M35 concrete as per IRC- 112 2020
2.	Allowable stress in Steel	440 Mpa for Fe 550 steel as per IRC – 112-2020
Limit State Design is Adopted for foundation As per IRC- 112. Load Combinations as per IRC:6 2017, Table B 3.1 to B 3.3		

6.15.4. General Design Criteria

general design criteria's		
1.	Maximum pile capacity(Vertical, Horizontal and Uplift) are as per Geotech report and increase in pile load for wind & earth quake considered as per IRC – 78-2014	
2.	Clear cover for reinforcement	75mm.

6.14.5 Pavement Design:

The flexible pavement is designed as per IRC:37-2018 for a cumulative design traffic of 30 MSA and a subgrade soaked CBR = 8% (reliability, lane distribution and growth assumptions as per code). Shoulder and drainage provisions are compatible with the main carriageway to preserve the design life.

Pavement crust: - proposed curst details

Bituminous Concrete (BC): 40 mm

Dense Bituminous Macadam (DBM): 95 mm

Wet Mix Macadam (WMM): 250 mm

Granular Sub-Base (GSB): 200 mm

Prepared Subgrade: 500 mm

6.14.6 Overlay

An asphalt overlay is proposed over the existing carriageway to restore structural capacity and riding quality. The design follows IRC practice for overlays on flexible pavements.

Bituminous Concrete (BC): 40 mm

Profile correction Course Dense Bituminous Macadam (DBM): 60 mm

6.16. Reference Codes

- IRC:37-2018 "Guidelines for Design of Flexible Pavements"
- IRC: 86-2018 "Geometric Design Standards for Urban Roads

and Streets"

- IRC: 92-2017 "Guidelines for the Design of Interchanges in Urban Areas"
- IRC: 106-1990 "Guidelines for Capacity of Urban Roads in Plain Areas"
- IRC: 5 – 2015: Specifications and Code of Practice for Road Bridges (Section-I)
- IRC: 6 – 2017: Standard Specifications and Code of Practice for Road Bridges, Section-II Loads and Load Combinations.
- IRC: 112 – 2020: Code of Practice for concrete Road Bridges
- IRC: 78-2024 Part 1: Standard Specifications and Code of Practice for Road Bridges, Foundation and Substructure.
- IRC: 78-2020 Part 2: Code of practice for limit state of design of foundations
- IS: 456 - 2000 Code of Practice for Plain and Reinforced Concrete
- IS: 2911 (Part I/Sec 2) - 2010 Code of Practice for Design and Construction of Pile Foundations
- IRC: 83 (Part - III) and Part IV: Code of Practice for Road Bridges-Section IX – POT cum PTFE Bearings and Spherical Bearings
- IRC: Sp-65 -2018: Guidelines for Design and Construction of Segmental Bridges
- **NF P 18-470 – 2016: Concrete — Ultra-high-performance fibre-reinforced concrete — Specifications, performance, production and conformity**
- **NF P 18-710 – 2016: National addition to Eurocode 2 — Design of concrete structures: specific rules for Ultra-High-**

Performance Fibre-Reinforced Concrete (UHPFRC)

- IRC SP-50 – 2012: For drainage Design
- SP 16 – 2019 Guidelines on Measuring Road Roughness and Norms
- IRC: 35 - 2015 for Road Marking
- IRC: 65- 2017: Guidelines for Planning and Design of Roundabouts for Road Signages

CHAPTER – 5 – ALIGNMENT OPTIONS

Chapter – 5 – ALIGNMENT

5.1. General

Traffic data collected at the junction from the traffic survey and its analysis shows that the intersection remains congested for considerable duration of the day. The volume of traffic is expected to increase, as a result of which congestion and delays at the junction increases. This would further lead to increased level of pollution and accidents. It is the right time for taking up necessary measures to reduce the congestion at the intersection by enhancing the capacity/ reducing conflicts and delays at the junction in order to avoid future traffic problems. The capacity of an intersection can be increased by segregating major conflicting traffic movements and segregation of traffic can be achieved by the construction of grade separators.

5.2. Constraints at Site

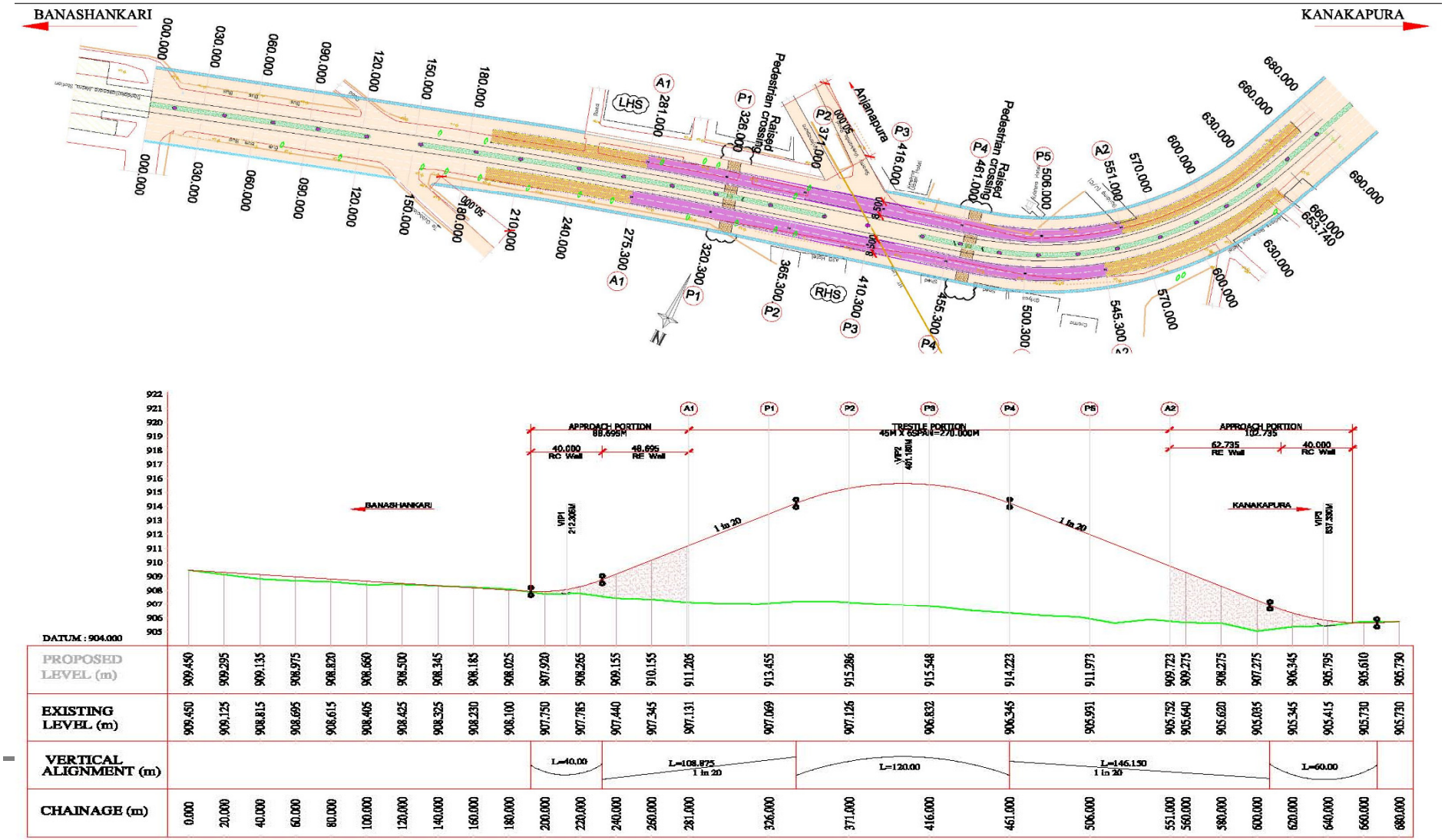
The following constraints were kept in mind while deciding on the alignment for improving traffic circulation for Proposed Elevated Corridor (Flyover) at Adyar Ananda Bhavan Raghuvanahalli cross, Kanakapura Road–

- There are commercial Establishments on either side of the roadalong Kanakapura Road.
- At A2B junction, there is existing Metro Green line, and Metro stations.
- High tension line crossing across the junction.

- Improvement shall be proposed only towards the ROW on east and West side of Kanakapura road with Land acquisition for approaches.

5.3. Alignment

5.3.1. Plan & Profile.



The Alignment shown above is the only feasible solution to ease the traffic congestion at junction as there are constraints to have different options, since the presence of green line metro and metro station along median, and limited availability of ROW

Advantages

- Vehicles moving between Banashankari and Kanakapura can pass smoothly without signal interruptions, ensuring continuous traffic flow.
- Segregation of through traffic onto the flyover reduces pressure on the at-grade junction, minimizing traffic buildup.
- Anjanapura Road and local at-grade traffic are managed by a limited signal system, reducing signal cycle time and waiting period.
- By providing flyovers on either side of the metro (instead of the center), vertical clearance issues are avoided, making the design feasible.
- Separation of heavy through traffic from local/cross traffic reduces conflict points and accident risks at the junction.
- Properly designed ramps with sufficient length provide safe merging/diverging, reducing chances of bottlenecks near the metro station.
- Placement of flyovers on either side of the metro ensures effective use of ROW without disturbing metro structures.
- With the proposal of 2 independent Fly overs for through traffic in both the direction will ease the traffic congestion at junctions with the elimination of 2 conflicts due to right turning movement of vehicles

CHAPTER- 7 – STRUCTURAL SYSTEM OF FLYOVER

CHAPTER- 7 – STRUCTURAL SYSTEM OF FLYOVER

7.1 General

The proposed project is inside the city area. The following points are viewed in selecting structural system for the project –

- The Project under study is very important connection to various parts of the city and complete diversion of traffic is not feasible.
- The construction method and system shall allow the movement of vehicles during construction period with minimum hinderance.
- The construction shall be Precast / prefabricated and segmental to minimise the construction period.
- The precast / prefabricated units shall have high strength to weight ratio.
- Easiness of transportation and erection of precast / prefabricated units.
- Apart from above points it should suit urban architecture with minimum Span to depth ratio

7.2 Drainage System.

Presently Elevated Stretch is having both sides drain and we have not disturbed the flow and alignment of drain. Only proposed new drain where land acquisition / widening of road is necessity.

It is proposed Drainage spouts at interval satisfying the codal guidelines with PVC down take pipe connected to grade level drain to drain out the elevated road rain water.

7.3 Span Arrangement

Span arrangement of 60m and 45.0m is studied and discussed with authority, 45m span is proposed from the following point of view–

1. Depth of Super structure for 60m is 3.1m, looks bulky with vertical clearance of 5.5, which will affect the aesthetics.
2. The foundations are proposed parallel to existing metro line.

7.3 Options of Super structure.

Following options are studied –

	Span	Structure Type
Option – 1	30	Segmental Box
Option – 2	45	Composite Steel Girder
Option – 3	45	UHPFRC

*for comparison purpose, Deck width of 17.2m has been considered-

7.3.1 Option – I: Segmental Box Girder

- Construction Speed: The use of precast segments allows for rapid on-site assembly, significantly reducing construction time.
- Traffic Disruption: Minimal on-site activity and a smaller footprint mean less disruption to traffic, making it ideal for urban areas.
- Quality Control: Manufacturing in a controlled factory environment ensures high-quality segments with consistent strength and durability.
- Aesthetics: The slim, clean lines of a segmental box girder can be aesthetically pleasing.
- Cost: The initial investment for casting yards and specialized equipment is high. **The size and weight of the segments will pose challenges for transportation and handling.**

7.3.2 Option – III: Composite Steel Girder

- Weight: Steel is lighter than concrete, which can reduce the size and cost of foundations and supporting piers.
- Long Spans: This is an excellent option for long spans where the self-weight of a concrete structure would be too high.
- Fabrication: Steel girders are fabricated off-site, which allows for faster on-site erection.
- Maintenance: Steel requires regular inspection and maintenance, such as painting, inspection of joints to prevent corrosion, adding to long-term costs.
- Cost: Steel is a more expensive material than concrete, which can increase the initial project cost.

7.3.3 Option – IV: Composite U-Trough UHPFRC+HPC Slab

- Structural Efficiency: The use of Ultra-High Performance Fiber Reinforced Concrete (UHPFRC) allows for a thinner and lighter structure, reducing dead load on foundations.
- Durability: UHPFRC is extremely dense and resistant to deterioration from chemical attacks, leading to minimal maintenance.
- Construction Speed: The precast U-trough segments can be assembled very quickly, drastically shortening the construction schedule.
- Ease of Transportation: The lightweight nature of the UHPFRC sections makes them easier and more economical to transport from the casting yard to the construction site. This simplifies logistics and reduces costs associated with Transportation.
- Cost-Effectiveness: While the initial cost of UHPFRC may be comparatively higher compared to first 2 options, the reduced material

usage, faster construction, and minimal maintenance lead to a lower total life-cycle cost, making it the preferred option.

7.3.4 Preferred Option:

Considering minimum inconvenience to grade level traffic during construction, quality of construction, low maintenance requirement, speed of construction, aesthetics**, "U-Trough UHPFRC" construction (i.e., Option –IV) is the preferred option.**

7.3.6 Superstructure Comparative Study of Cost

Item of Work	Unit	Option - 1			Option - 2		
		Quantity	Rate	Cost	Quantity	Rate	Cost
M50 Concrete	Cum	361.9	14200	□ 51,38,980	320.85	14200	□ 45,56,070
UHPFRC-M150	Cum						
Untensioned Steel	MT	82	95325	□ 78,16,650	64.2	95325	□ 61,19,865
Prestressing steel	MT	15	257639	□ 38,64,585	23	257639	□ 59,25,697
Structural Steel	MT						
				□ 1,68,20,215			□ 1,66,01,632
			Rate/Sqm	□ 32,598			□ 32,174

	Unit	Option - 3			Option - 4		
		Quantity	Rate	Cost	Quantity	Rate	Cost
M50 Concrete	Cum	194	14200	□ 27,54,800	248	14200	□ 35,21,600
UHPFRC-M150	Cum	0	97451	□ 0	152	97451	□ 1,48,12,552
Untensioned Steel	MT	30	95325	□ 28,59,750	50	95325	□ 47,66,250
Prestressing steel	MT	0	257639	□ 0	25	257639	□ 64,40,975
Structural Steel	MT	310	171080	□ 5,30,34,800			
				□ 5,86,49,350			□ 2,95,41,377
			Rate/Sqm	□ 75,775			□ 38,168

From the Above comparison, comparing direct cost, of construction option 1 and 2 is having least cost. Option-3 is cost prohibitive to adopt for the entire corridor. Option-4 with 45m UHPFRC composite super structure the cost of super structure is about 15% higher compared to option-2. However, there will be reduction in cost of sub structure Super structure with UHPFRC composite i.e., **U- trough with UHPFRC and top slab with M50 is recommended with following advantages.**

1. Sleek sections and elegant appearance of structure.
2. Significant reduction in the weight and hence suitable for long spans.
3. Ensures high quality of concrete as it is produced with less w/c ratio in a controlled environment.
4. Attains early strength and hence faster construction cycle which reduces construction period.
5. Life cycle cost is less as the maintenance requirement for UHPFRC is negligible
6. Significant reduction of Shrinkage and creep.

Though cost of construction for Composite steel super structure is more, composite structural steel super structure is proposed for elevated rotaries, rotary adjacent spans, at few critical locations keeping ease of construction point of view.

7.3.7 Sub structure and Foundation

Sub structure is proposed with RCC single rectangular pier and pier beam. For foundation 1200 dia piles are adopted.

7.3.8 Bearings & Expansion joints

Mechanical Bearings, spherical bearings are considered, and Slab seal expansion joints are used.

CHAPTER- 8 – TRAFFIC DIVERSION AND MANAGEMENT PLAN

CHAPTER- 8 – TRAFFIC DIVERSION AND MANAGEMENT PLAN

8.1. General

The projects under the consideration for Proposed Elevated Corridor (Flyover) at Adyar Ananda Bhavan Raghuvanahalli cross, Kanakapura Road

Fly over along Kanakapura Road accommodating through traffic on east side and west side of the Kanakapura road is proposed. The Sub structure is with Single pier and Super structure is with Composite UHPFRC and HPC concrete. Pre cast technology for Super structure is proposed to minimise the disturbance during the construction.

- Precast technology is adopted which will be erected using Over head launching girders/underslung system.
- Existing service roads will be resurfaced and new service roads for construction purpose will be formed
- Constructing the new service roads wherever there is no existing service roads
- Barricading the construction site
- Deployment of Flagmen
- Proper signages at the working area indicating diversions and other cautionary sign boards.

traffic management shall be planned as there are no alternative roads for diversion.

Traffic management may be under following guidelines during various phases –

8.2. Traffic Management during Construction.

8.2.1 Phase – I: Widening and reconstruction of existing carriage way and construction of foundation

Hard barricading and safety measures are proposed in the construction area, allowing the traffic movement along the existing carriage way.

8.2.2 Phase – II: Construction of Viaduct is planned during this phase.

Hard barricading and safety measures are proposed in the construction area, allowing the traffic movement on either side over existing and extended carriage way.

8.2.3 Phase – III: Reconstruction of grade level roads is planned during this Phase.

The Traffic will be allowed on the completed grade separators/ fly over and cross roads will be remodelled along with the necessary junction improvements.

The above scheme of traffic management is tentative which is to be approved by the traffic police and the responsibility of approval and implementation rests with construction agency.

CHAPTER- 9 – LEGAL ASSESSMENT

CHAPTER- 9 – LEGAL ASSESSMENT

9.1. Land Acquisition

Proposed Flyover at A2B Raghuvanahalli junction for through traffic from Kanakapura to Banashankari

The Project Area lies in Well Developed Residential as well as in Commercial Area with 7947 Sqm of private land needs to be acquired under Transfer of Development Rights (TDR) Scheme.

9.2. Enforcement Measures

B-SMILE has planned to take Precautionary Measures during the Construction Phase to enforce Traffic Diversion and minimizing the effects of various Pollutions. Through the Institutional Framework suggested, B-SMILE will coordinate with the Traffic Police, BMTC and Utility Operators like BESCOM, BWSSB for the Shifting of Existing Utility Lines, which are going to obstruct the Execution of the Project. Since BSMILE is the Obligatory Provider of Citizen Services in the City, it has powers by statue to require other Government and Non-Government Agencies to implement Plans in Public Interest. B-SMILE has also notified the List of Underpasses and Flyovers that it proposes to construct and thus it is making the Residents and Commercial Establishments aware of the possible disturbances that could emerge on account of the Implementation of the Projects.

Stake holders along the corridor whose utilities are crossing the present proposal viz., KPTCL, BESCOM, BSNL , etc., are informed regarding the project with a letter and set of project drawings and costing towards necessary utility shifting are accounted in the DPR

CHAPTER- 10 – RISK ASSESSMENT

CHAPTER- 10 – RISK ASSESSMENT

10.1. General

In a Road Project there are considerable risks involved during the implementation of the project. The risks during the operation phase are minimal and restricted to over use of the road (against Design Assumptions) by heavier vehicles and damage to road surface by accidents and by vehicles carrying overload. In the current elevated road projects undertaken by B-SMILE, the time frame for completion work in 12 months after mobilization of site resources. The major risk relates to buy in of the project from all stakeholders, especially those affected by the construction itself. These are residential and commercial establishments who are close to the construction site. They are exposed to noise pollution, dust pollution and inconvenience caused due to inability to use their vehicles on account of temporary closure of the roads.

Internal Risks come mainly from three sources: the Project, the Organizations Involved and the Relationships among Partners. Most projects suffer at least temporarily from a deficient project structure: many are launched even though objectives are not clear, a business case had not been completed, and milestones were only vaguely defined, if defined at all. These instances of lack of or inadequacy in definition of scope occur due to pressure to complete the planning stage and to go ahead with the construction early. On the organizational side, lack of project control mechanisms is the factor that most impede many projects. Finally, risks associated with the relationships among partners have been the major source of concern present in all projects, lack of definition of role

and responsibility as the most important problem for project implementation.

The Risks associated with the road projects fall into four categories.

- Multiple Stakeholder Coordination Risk during execution of work (very critical in the road projects of Bangalore).
- Project Risk (Clarity in Scope, Clarity in Role and Responsibility).
- Acquisition of Land and Removal of Encroachments while Widening the Drains.
- Shifting of Utilities – Perfect Coordination among the Concerned Stakeholders and the Contractors.

10.2. Stakeholders

The Stakeholders involved in the Bangalore Road Projects are:

- B-SMILE.
- Utility Companies.
- Traffic Police.
- Public Works Department.
- Residents' Association.
- Shop Owners' Association.
- Pollution Control Board.

10.3. Role of Traffic Police

Coordination with the Traffic Police, Liaison with Residents and Shop Owners' Association is a pre requisite before commencing the Construction Phase. Traffic Police will have to plan for Diversions/management of traffic, Construction of Temporary Structures, and Regulation of Traffic during Peak Hours with Extra Resources, etc. Communication through Media and Door – to – Door Campaign in the affected areas are proposed to ensure smooth Construction Phase.

Traffic Police will also have to develop alternate routing for the BMTC Buses that ply in the roads proposed for revamping. They need to mark the zones near the Construction Site as 'No Parking' and allocate Routes and Space for the Vehicles engaged in the Construction Work.

10.4. Shifting of Utilities

In Bangalore Road Network, the common Utilities that are encountered during the revamping or widening are

- Sewer and Drainage Lines.
- Water Supply Lines.
- Electricity Lines and Structures (Mounted Transformers).
- Telecommunication Lines and Structures.
- Street Lights.
- Parking Signs.
- Post Boxes.
- Signals.

The utilities are to be shifted in coordination with the Concerned Departments. The key is in sending them advance communication and obtaining their sign off for proposed shifting well ahead of the Construction Phase. Underground utilities are the main concern and pose a major challenge that will need the commitment and cooperation of all the associated Departments. Shifting of underground utilities are to be executed in coordination with BWSSB, KPTCL, BESCOM, BSNL and other private Telecom Operators like Bharti, Tata, Reliance, etc., which have led OFC cables along the existing roads.

10.5 Risk Management

Risk	Stakeholders	Severity of Risk	Solution
Acquisition of Land	B-SMILE, Government of Karnataka	Medium	A Combination of Enforcement and Rehabilitation measures is required to notify the affected people and provide Alternate Arrangements for living. In the case of road projects the instances are minimal.
Removal of Encroachments	B-SMILE, BDA, Government of Karnataka	Medium	Legislation followed by proper Enforcement; affected people to be considered for Housing under Basic Services to Urban Poor Plan.
Traffic Management	B-SMILE, Contractors, Traffic Police	High	A Well-Coordinated Traffic Management Plan with clearly Defined Roles is required. Participation of Residents and Shop Owners at the Formulation Stage is also recommended.
Risk	**Stakeholders**	**Severity of Risk**	**Solution**
Accident Free	B-SMILE, Contractors, Traffic Police	Medium	Proper Deployment of Resource at critical periods of time and Inspection of Vulnerable Structures and Traffic Diversion Routes.
Dumping of Construction Debris	B-SMILE, Contractors	Medium	Storage Space shall be allocated along the Construction Site, Instructions for Clearing and Dumping the Debris Outside the Construction Sites shall be issued.
Protection of	B- SMILE,	Medium	The water pipe line of larger

Pipe line	BWSSB and Contractors		diameter along the pipe line corridor shall be protected by MS encasement at pile and pile cap location
Compound wall	B-SMILE, Contractors	Low	Wherever construction is in close proximity to the structure and in forest area compound wall to be constructed

10.6 Internal Risks associated with Road Projects in Bangalore City with Suggested Measures to Address the Risks

Risks Associated with the Project itself	***Characteristics of Clients / Users of the Service:*** Resistance to Change, Lack of Involvement, Inadequate Education Level, Difficulties in Communicating, Unrealistic Expectations. (To overcome B-SMILE is seeking Citizen Participation through Ward Committees and others for Buy In the Project and Speedy Implementation). ***Scope of the Project:*** Universality or Specificity of the Service, Number of Partners Involved, Number of Clients, Size of Budget. (Contract Documentation being revamped to define the Role and Responsibility very clearly emphasizing on the need to communicate with the Stakeholders at the Critical Times). ***Complexity of the Project:*** Especially Organizational and Technological Complexity. (Consultant would evaluate various assumptions made in the Design and Detailed Engineering while executing the Project and provide Feedback to B-SMILE). ***Definition and Structure of the Project:*** Unclear Objectives, Ill Defined Specifications and Functional Requirements, Changes in the Scope or the Reach of the Project, Difficulties in Integrating Data or Processes. (Flexibility to Accommodate Changes by the Contractors included in the Contract Documentation).
Organizational Risks	***Lack of Resources:*** *U*ncertainty of Funding, Inadequate Resources, Lack of Expertise in Complex Resource Management (these may not be critical under State Govt Funding). ***Project Team Competencies:*** Lack of Experience, Expertise, Stability and Communication Skills. (It is proposed to establish a PMU for Road Projects within B-SMILE with Requisite Skills and Experience). ***Management Strategy:*** Inadequate or Inappropriate Organizational Support and Control, Absence of a Champion, Lack of Leadership, Unavailability of Tested Management Tools and Processes. (Inter Institutional Committee proposed to deal with Policy Level Decisions

	including Release of Funds from the State Government). ***Technological Know How:*** Absence of an Adequate Technological Infrastructure and of In-House Technological Competencies. (Competencies being Upgraded as well as Latest Construction Practices followed in Road Construction, Material Handling and Disposal of Construction Debris).
Relationship Risks	***Form of Collaboration:*** Inadequate or Inappropriate type of Agreement, Misunderstandings regarding the Content of the Agreement, Inappropriate Selection of Partners, etc. (All Contractual Frameworks to define the Role, Responsibility and Liability of Various Parties clearly; Contractors to be provided with Opportunity to seek Clarification before Accepting the Work). ***Collaborative Process:*** Problems occurring with Coordination, Communications, Inertia, Dependency, Mistrust, Lack of Consensus or Involvement (Change Management Process proposed to be handled by the PMU).

CHAPTER- 11 – ENVIRONMENTAL AND SOCIAL IMPACTS

CHAPTER- 11 – ENVIRONMENTAL AND SOCIAL IMPACTS

11.1. General

In any major developmental initiative aimed at promoting the interests of the community or the State / Country, the Associated Environmental Impacts – whether of a Short Term or Long-Term Nature, likely to affect the Environment, Ecology and Health of the Community, need to be seriously examined, before embarking on the proposed project. The Primary Objectives of the Environmental Impact Assessment (EIA) are to evaluate the existing preoperational baseline environmental status at the proposed project site by field studies and data collection and then carry out an Objective Assessment of the various impacts on the Environment as a result of the proposed activities. As "Construction of Proposed Elevated Corridor (Flyover) at Adyar Ananda Bhavan Raghuvanahalli cross, Kanakapura Road for through traffic from Kanakapura to Banashankari is one of the major Metropolitan Infrastructure Projects for Bangalore, proposed by B-SMILE, it is imperative to conduct an Environmental Impact Assessment (EIA) to quantify the Benefits accrued to the Community as a result of the Project, while at the same time analyzing carefully the Impact Aspects due to the Project itself, during Construction and Operation Phase Cycles. As these Data are crucial for the Planning and Successful Implementation of the Project, Various Data (such as Nos. of Tree Cutting, Extent of Air and Noise Pollution, etc.) have been collected from extensive site studies in accordance with well-established Standard Procedures.

The existing road infrastructure on Kanakapura road have deteriorated remarkably as a result of lot of investment and multifield increase in traffic volume, number of major junctions. The junctions and the existing road have to be upgraded to higher service levels in order to reduce transport cost in support of Socio-Economic Development.

Discussions held with Government and Non-Governmental Organizations and a Detailed Site Assessment have been carried out to provide the basic background for Impact Identification and Assessment. A Scoping Exercise has also been carried out at the Pre-Construction Stage to identify and highlight the Key Issues and Impacts likely to occur during the Construction, Operations and Maintenance Phases of the Project, as well as to identify those Impacts which could, but are unlikely to occur. Practical and Cost-Effective Benefit Enhancement and Mitigation Measures have been identified and outlined, taking into account alternative approaches that are appropriate to the situation. A Management and Monitoring Plan was developed to provide a sound basis for ensuring that the specified benefit enhancement and mitigation measures are fully adopted.

For Planning and Implementation of “Flyover corridor”, due attention is given to the Environmental and Social Issues. The Various Issues addressed under this Section are as follows.

11.1.1. Green Cover

Bangalore City – with its rich flora and abundant green cover and being host to Lalbagh and Cubbon Park, which are renowned botanical gardens, is rightly called the "Garden City of India". Bangalore City bagged the Central Government sponsored "Indira Priyadarshini Vruksha Mitra" Award in the late 1980s in recognition of its extensive green cover. But today, lung space is shrinking in the city and core areas have lost green cover with increase in concrete structures. As a part of this project, to acquire obstruction free area, 05 trees to be cut in the project area. Considering the Benefits of the Project and the Compensatory Afforestation Plan envisaged, it has been observed with management plans consisting of planting of trees in the ratio of 1:2, proactive afforestation for green cover and development of green ribbon in and around the project area, it will be abundantly compensating the green cover. Land required in the developed forest area at the approaches towards the end chainage of elevated corridor. Land acquisition proposal in this area has been made only for the required extent and to avoid tress passers, compound walls have been proposed. For number of trees to be chopped, afforestation and translocations of trees have been planned.

11.1.2 Air Pollution

Air Pollution level will go up during the Construction Stage due to operation of construction yards, material transport on trucks and due to heavy earth moving machinery exhaust emissions (e. g. SPM, RSPM, NO_x, SO_x, CO, etc.) from the construction sites. These are not permanent in nature, but minor, temporary and mitigatable. In the post construction scenario, the General Level of Air Pollution in the project area will be

significantly less than the current level due to improved movement of vehicular traffic and removal of idling time and thus this project ensures better environment. The Consultant has collected data regarding existing Air Quality in and around the project is studied. All vehicles delivering materials to the site will be covered to avoid spillage of materials. All existing highways / roads used by vehicles of the Contractor, or any Sub Contractor or Suppliers of Materials or Plant and similarly Roads, which are part of the Works, will be kept clean and clear of all dust / mud or other extraneous materials dropped by such vehicles. The unloading of materials at construction sites close to settlements will be restricted to night time only. Vehicles and Equipment will be fitted with Exhaust Silencers. During routine service operations, the Effectiveness of Exhaust Silencers will be checked and if found defective will be replaced. Unpaved Haul Roads near / passing through residential and commercial areas to be watered thrice a day. Trucks carrying construction material are to be adequately covered. All Earthworks will be protected in a manner acceptable to the Engineer (such as Barricading the Construction Site) to minimize Dust Nuisance in the surrounding area. The Contractor will take every precaution to reduce the Level of Dust along Construction Sites involving Earthworks, by frequent application of water.

11.1.3 Water and Soil pollution

The Surface and Underground Water and Soil Pollution Aspects are not likely to be greatly influenced, unlike Air Pollution Quality by the Construction, However, there could be Indirect Impact on the Water and Soil Components in the long run.

As the Project Activities need substantial water quantities for construction processing, dust proofing, cleaning of vehicles and batch mixing, etc.

there could be considerable demands on water resources available. Necessary arrangements and contingency plans with BWSSB and Arrangement for Supply of Recycled Water should be made to meet the Water Demands, without in anyway affecting the city's normal water supply demands.

With the proposal of UHPFRC (Ultra High Performance Fibre reinforced concrete), HPC (High Performance Concrete) and Composite steel girders, water requirement is minimised. With the proposal of Pre cast UHPFRC, where curing will be with steam curing, recycling of the water can be made there by reduction in the water requirement.

All the Proposed Project Components will be in Well Developed/fastly developing Areas of the City with Distinct Land Usage Patterns ranging from Residential to Commercial Activities under Well Established Conditions. As Construction Activities are primarily land based, many Impacts can be identified in the Soil Component in the Proposed Area. Excavation Activity will produce a lot of rubble from excavated soil, needing disposal. The excavated soil / debris will be disposed by covered trucks to avoid Dust Nuisance in the Project and Surrounding Areas. Debris generated due to the dismantling of the existing pavement structure shall be suitably reused in the Proposed Construction, subject to the Availability of the Material and the Approval of Project Engineer. The Contractor shall suitably dispose of Unutilized Debris Material; either through filling up of Borrows Areas created for the Project or at Pre-Designated Dump Locations, subject to the Approval of the Project Engineer. Debris generated from different Construction Activities shall be

disposed of in such a way that it does not flow into the Surface Water Bodies or form Mud Puddles in the area.

As the concrete used for sub structure is from RMC, water required only for curing purpose only. For Curing purpose, potable water shall be used and percolating water will not pollute the ground water table.

11.1.4 Noise Pollution

As the Project involves significant uses of Heavy Machineries, Traffic Diversion, etc. hence Noise Concern will be a major issue during Construction Phase. But the Post Construction Scenario ensures a Better Environment in the Project Area, as the General Level of Noise Pollution in the Project Area will be significantly less than the Current Level due to Improvement in the Movement in Vehicular Traffic and Removal of Idling Time. The Consultant has collected existing Noise Level Data in and around the Project Area and is given Table 11.4. to 11..6 To mitigate the Noise Impact, Direct Technical Remedies including Low Noise Road Surface, Road Covers and **Roadside Noise Barriers will be provided**. Noise Limits for Construction Equipment used in this Project (measured at one metre from the edge of the equipment in free field) such as Compactors, Rollers, Front Loaders, Concrete Mixers, Cranes (movable), Vibrators and Saws will not exceed 75 dB (A), as specified in the Environment (Protection) Rules, 1986. Notwithstanding any other Conditions of Contract, Noise Level from any Item of Plant (s) must comply with the Relevant Legislation for Levels of Noise Emission. The Contractor will ensure that the AAQ Concentrations as these Construction Sites are within the Acceptable Limits of Industrial Uses in case of Hot

Mix Plants and Crushers and Residential Uses around Construction Camps. Noisy Construction Operations in Residential and Sensitive Areas (Hospitals, Schools and Religious Places) should be restricted between 0730 hrs. and 1800 hrs. Preventive Maintenance of Construction Equipment and Vehicles would be done to meet Emission Standards and to keep them with Low Noise. Earplugs will be provided to Operators of Heavy Machinery and Workers in near vicinity. Material Transport should be uniformly distributed during nights to minimize Noise Impacts. Noise barriers will be proposed at required locations in discussion with clients. Mainly near the Schools, Residential developments, Hospitals and Temples.

Part of the Costs, particularly the Implementation of Environmental Measures is included in the Unit Rates for the Works and is responsibility of the Contractor.

11.1.5 Social Impact

The Direct and Indirect Job Opportunities that will be provided by the Project can be considered as a Positive Aspect. The Local People will be directly employed to work at the Construction Sites and others will be employed in Sectors of the Economy, which have been developed by the Road such as the Service Sectors. Some individuals may gain skills that can be applied in other Road Construction Projects.

Contract Documentation will be crafted in such a way that the Construction Work does not cause undue Inconvenience to Residents, especially the Sick and Old People. Removal of Construction Debris promptly from the Site falls within the Scope of Work of the Contractor. Asphalting, the Major Work, involved in the Road Construction would invariably be carried out during the nights with Proper Inspection Team supervising the Process.

The table below summarizes the Negative Environmental and Social Impacts and Mitigation / Benefit Enhancement Measures for the Negative Impacts, as well as the responsible body to implement the measures.

Type of Impact	Mitigation Measure	Responsible Body for Implementation
Impact on Settlement	Minimize the Risk at the Road particularly in a Dense Settlement Area.	Consultant and Contractor.
	Allow Affected Persons to Salvage Building Materials and other Assets.	B-SMILE and Contractor.
	Pay Compensation and Resettle the Affected People.	B-SMILE.
Impact on Health	Do not Induce Water Related Diseases by creating Temporary and Permanent Water Holding Areas, which favour Mosquitoes.	B-SMILE and Contractor.
	Minimize Dust Emission by Watering the Road during Construction.	Contractor.
	Put Visible and Appropriate Warning Signs on the Road during Construction.	Contractor.
Impact on Existing Infrastructure	Relocate Power Lines, Telephone Lines and Water Points before Commencing of the Road Construction and in few cases during the Construction Phase.	Utility Companies and Contractor.
Impact on Cultural, Religious and Archaeological Resources	Design Roads to avoid such Sensitive Places.	Design Consultant.
Road Safety during Construction and Operation Phase	Install Road Safety Signs at all Accident Prone Spots as Installation / Erection of Safety Signs.	Traffic Police / Contractor.
	Provide Traffic Awareness.	Contractor in collaboration with Traffic Police of the Area and Local NGO.

	Use Clear, Properly Labelled and Meaningful Traffic Signs and Speed Limits, especially at Pedestrian Road Crossing.	Contractor in collaboration with Traffic Police of the Area.
	Assign Traffic Personnel to regulate the Passage of Construction Vehicles (carrying debris as well).	Contractor in collaboration with Traffic Police of the Area.
	Construct Half of the Road while the other is used for Traffic where feasible.	B-SMILE and Contractor.
Social Impact from Migrant Workers	Construction Workers will be given Health Awareness.	NGOs in collaboration with the Contractor.
	Avoid accommodating Labour Force in or directly adjacent to Construction Sites.	Contractor.
	Recruit Work Force from the Local Community giving more chances to Women.	B-SMILE and Contractor.

CHAPTER- 12 –PARTICIPATION OF BENEFICIARIES

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- Any Infrastructure Development Activities of B-SMILE are planned and implemented through Community Participation Process. Local Government Institutions at various levels are involved in the Implementation of Projects. Moreover, NGOs are involved to assist B-SMILE in Social Mobilization Aspects for Planning and Implementation of the Project. As a part of Participatory Development, Beneficiary Groups and User Committees, such as Labour Contracting Society, Market Management Committee, Road User's Committee, Water Management Committee, etc. have been consulted under various Projects of B-SMILE. Involvements of the Private Sector, Local Government Institutions, NGO and Beneficiary Groups have significantly contributed to Smooth Planning, Implementation and Operation / Maintenance of Infrastructure Development Schemes of B-SMILE at the Local Level. Consultation with various Stakeholders has been an Integral Part of Project Formulation Phase. People have been interviewed along the route, including Elders and Elected Members of the Community; have given a positive reaction to Road Improvement. The Project corridor is very important in terms of connecting the National Highway towards Kanakapura. Social Acceptability of the Project is very high.

- This Project will have many Positive Impacts on Beneficiary Livelihoods and in the Potential Economic Expansion of the Region as it is not only aimed at through traffic. The project also aimed at connecting important roads along the corridor so that habitants of these area will highly benefitted to connect to the city as well outskirts of Bangalore towards Kanakapura. Beneficiaries of this Project include Bangalore Metropolitan

Transport Corporation (BMTC) Authority, Commuters using this stretch of road, Local People in and around of the Project Area.

- Public Opinion with regard to public projects cannot be ignored. It plays a very important role in the decision-making process. Given the chaotic road traffic on Kanakapura road, Public Opinion Survey will be conducted on the basis of a sample of cross section of intelligentsia drawn from Lawyers, Doctors, Engineers, Academicians, Journalists, etc. the Opinion Makers in Urban Situation upon finalisation of GAD after the approval TAC and B-SMILE. Interactive Sessions with NGOs and Various Members of the City Public also formed part of the Exercise in this Direction.

- Prior Information to the Public, before the Start of the Work, regarding the Project will be given through Paper Notification.
- Boards, comprising Important Data regarding the Project (such as Project Name, Name of the Agency executing the Work, Name of Local Government Body taken up the Project, Date of Commencement of the Project, Projected Date to Complete the Work, etc.) for notifying people will be displayed at the major junctions in and around the project area.

- Adequate actions to direct and regulate traffic shall be taken in consultation with B-SMILE / Traffic Police to prevent jamming roads during Construction Period. While planning alternative routes, care to be taken to minimize congestion and negative impacts at sensitive receptors such as Schools and Hospitals. Traffic Controls and Diversions marked with Signs and Lights and Other Measures (flags) should be provided. Prior to creating Diversions and Detours, the citizens will be consulted

well in advance through Citizen's Meetings. It should be an informed decision taken through Public Participation. The Temporary Traffic Detour will be cleaned regularly.

- Another significant aspect of the Construction of Elevated Corridor would be its Dislocation Effect on the existing public utilities like Electrical System Network (including Street Lighting), Sewerage Lines and Water Supply Network, etc. As the Public Utility Network are very vital for a normal functioning of an Urban Metropolis, a Detailed Survey of Existing Utilities and their Diversion or Reinstallation on a temporary or permanent basis should be planned in a proactive manner and organized with minimum loss of time and inconvenience to the community. Prior Information through Paper Notification will be given to the affected area people before shifting any Utilities.

- The Project is judged to be environmentally and socially acceptable.

CHAPTER- 13 – CONCLUSIONS AND RECOMMENDATION.

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13.1 CONCLUSIONS

The Project is highly beneficial to the road users and public. Therefore, the construction of proposed Elevated Corridor (Flyover) at Adyar Ananda Bhavan Raghuvanahalli cross, Kanakapura Road for through traffic from Kanakapura to Banashankari coupled with the traffic management will have the following additional benefits:

- Reduced junction delays and pollution due to vehicular traffic.
- Reduction in idle fuel consumption
- Improved level of service at the Junctions along the Kanakapura Road.
- Substantial savings in travel time for Road users
- Reduces the number of conflicts for through traffic.

PROPOSAL

- Separate 2-lane Fly overs for through traffic in each direction along Kanakapura road at A2B Raghuvanahalli Cross Junction

13.2 Recommendations and Conclusion

- Presently traffic along the Kanakapura road is heavy and through traffic is moving along the congested kanakapura road.
- Separate Fly overs, accommodating through traffic along Kanakapura road at A2B Raghuvanahalli Cross junction will decongest the junctions and reduces the signal timing and waiting time at the junctions.
- Noise level and pollution level at A2B Raghuvanahalli Cross Junction will be reduced as the through traffic is taken along elevated corridor

APPENDIX - 1 - TRAFFIC REPORT

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1. TRAFFIC SURVEYS AND ANALYSIS

1.1 INTRODUCTION

B- SMILE, Bengaluru Smart Infrastructure Limited, a Special Purpose Vehicle **(SPV)** created by Karnataka government, awarded the project "Consultancy Services for preparation of Report for "**Proposed Elevated Corridor (Flyover) at Adyar Ananda Bhavan Raghuvanahalli cross, Kanakapura Road "** to **M/s. NAGESH Consulting Engineers Pvt. Ltd, Bangalore** to carry out all engineering surveys.

The traffic survey was conducted using videographic approach to study the existing movement of traffic and to calculate the diverted traffic movement from existing roads to proposed fly overand the traffic survey data are presented in terms of Average Daily Traffic (ADT) and Peak hour traffic along the project road. These results of the analysis can be used or will form inputs for traffic forecast, determination of capacity analysis and design of other project proposals.

1.2 The Traffic Survey Location

The schematic diagram of traffic survey locations is given in **Figure 1.1**. Traffic surveys are conducted at selected locations along the existing Kanakapura Road. The list of surveys conducted is given in **Table 1.1** below.

Figure 1.1 Traffic Survey Location Plan

1.3 TRAFFIC SURVEY LOCATIONS

The following survey locations were selected for the traffic surveys and the schedule of traffic surveys is presented below.The following **Table 1.1** gives details of various traffic surveys conducted with period of survey.

Table 1.1 Schedule of Traffic Surveys

Sl. No.	Type of Survey	Duration	Location	Date(s) of Survey
1	Turning Movement Surveys	24 Hrs	A2B Junction	02.04.2025

1.4 SURVEY METHODOLOGY AND CONDUCT OF SURVEYS

The Origin and Destination survey was carried out manually by employing enough specially trained enumerators. An experienced traffic engineer was kept in charge while carrying out the surveys. The locations for the various surveys were selected based on the discussion with NAGESH Consultants and members from Jayanth Seelin Associates:

1.5 CLASSIFIED TRAFFIC VOLUME COUNT

The classified traffic volume count was carried using Videography method. Cameras were installed at the survey locations covering all traffic movements. The traffic data captured in the camera are downloaded to the computer after completing the survey. The captured data was counted manually at the office to obtain data on the magnitude of traffic flow, hourly variation and the traffic composition. The vehicles were broadly classified into various categories such as cars/jeeps/vans, buses, trucks, multi axle vehicles (MAVs), light commercial vehicles (LCVs), tractors, motorized two wheelers, auto rickshaws and slow-moving vehicles (SMVs) which includes cycles and carts.

1.5.1 Passenger Car Unit

A way of accounting for the interaction of various kinds of vehicles is to express the capacity of roads in terms of a common unit. Tentative equivalency factors for conversion of different types of vehicles into equivalent Passenger Car Units (PCU) based on their relative interference value. Table **1.2** presents the PCU factors (As per IRC: 106-1990) considered in the estimation of traffic intensity in PCUs.

Table 1.2 **PCU factors adopted**

Sl. No	Vehicle Category	PCU Factors
1	2-Wheeler	0.75
2	3-Wheeler	1.2
3	Car/Jeep/Van	1.0
4	Mini-Bus	1.4
5	Bus	2.2
6	LCV	1.4
7	2 Axle Truck	2.2
8	3 Axle Truck	2.2
9	4-6 Axle Truck	4.0
10	Tractor with Trailer	4.0
11	Tractor without Trailer	1.4
12	Cycle	0.4
13	Cycle Rickshaw	1.5
14	Animal Drawn	1.5
15	Animal Drawn	1.5
16	Others HCM/ EME	2.2

1.6 TURNING MOVEMENT COUNT SURVEYS

The surveys were conducted for one day (24 Hours covering morning and evening peak hours) to obtain classified turning movement at the identified junctions. The data derived from the survey will be analyzed to identify requirements of suitable remedial measures, such as construction of grade-separated intersections.

1.6.1 TMC – A2B RAGHUVANAHALLI CROSS

- A total of about 1,03,028 vehicles (97,094 PCU's) pass at this location per 24 Hours.
- Goods vehicles account for 6.04% and passenger vehicles account for 93.81% of the total traffic. Non-motorized traffic constitutes about 0.15% of total vehicles.
- Among the passenger vehicles, two wheelers and cars are the dominant ones constituting about 51.94% and 30.81%. Whereas Auto Rickshaw and buses (Minibus, Pvt. Bus, Govt. Bus) are at 11.06%.
- Morning Peak Hour at 09.00 AM to 10.00 AM (6.94%, Peak Hour Factor) and Evening Peak Hour at 18.00 PM to 19.00 PM (7.12%, Peak Hour Factor).

  Figure 1.2 and **Figure 1.3** shows Traffic Composition and hourly variation of traffic at location. Direction-wise Flow diagram is given in **Figure 1.4**to **Figure 1.5**

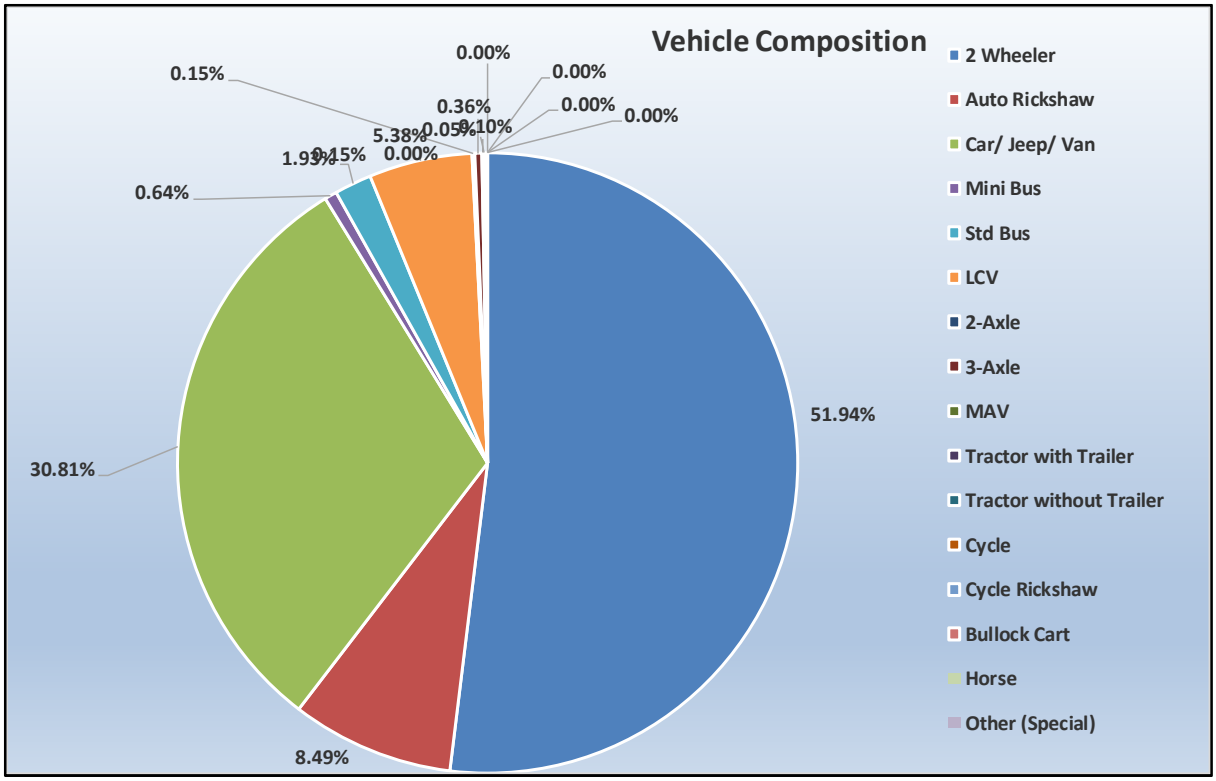

Figure 1.2 Traffic Composition at Adyar Aanand Bhavan Junction

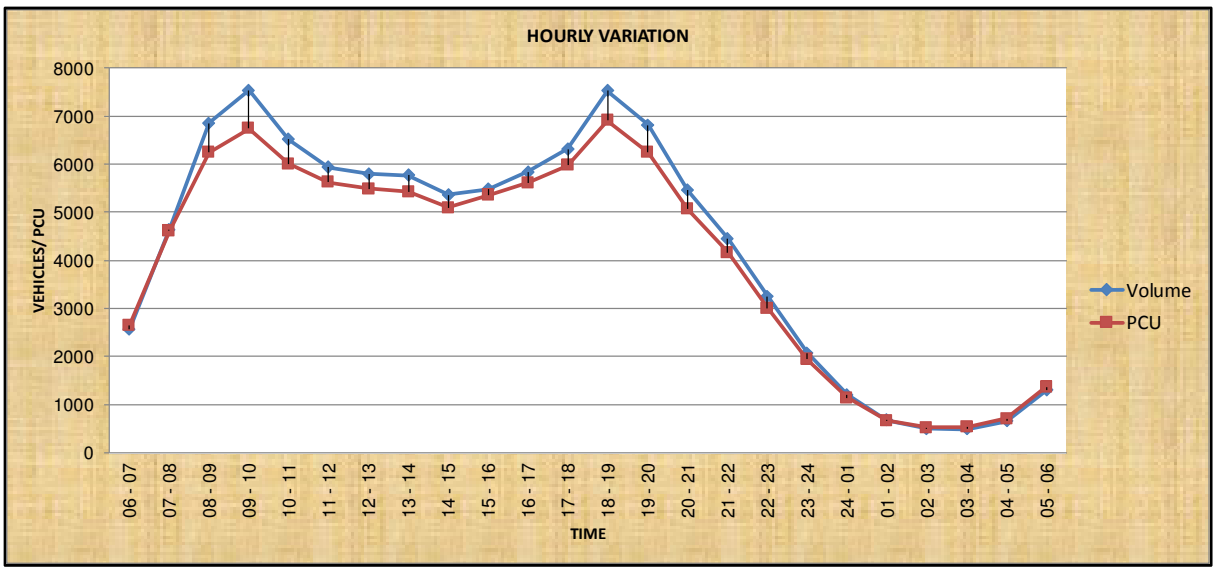

Figure 1.3 Hourly Traffic at Adyar Aanand Bhavan Junction

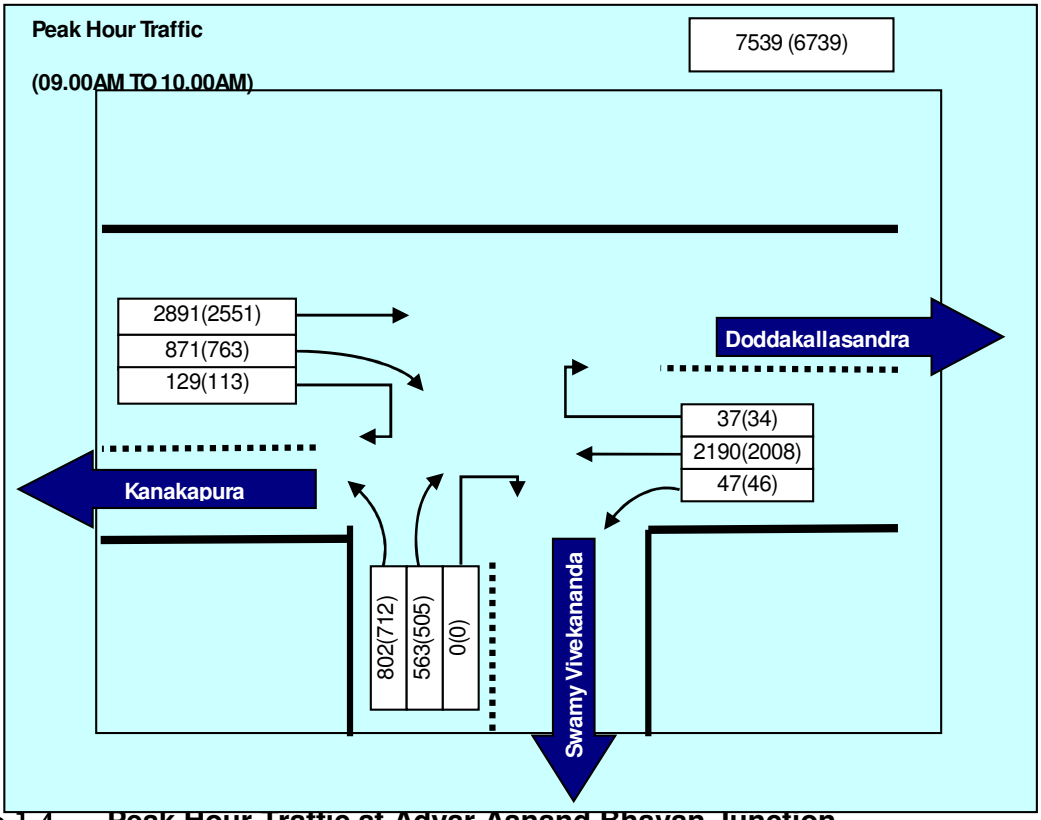

Figure 1.4 Peak Hour Traffic at Adyar Aanand Bhavan Junction

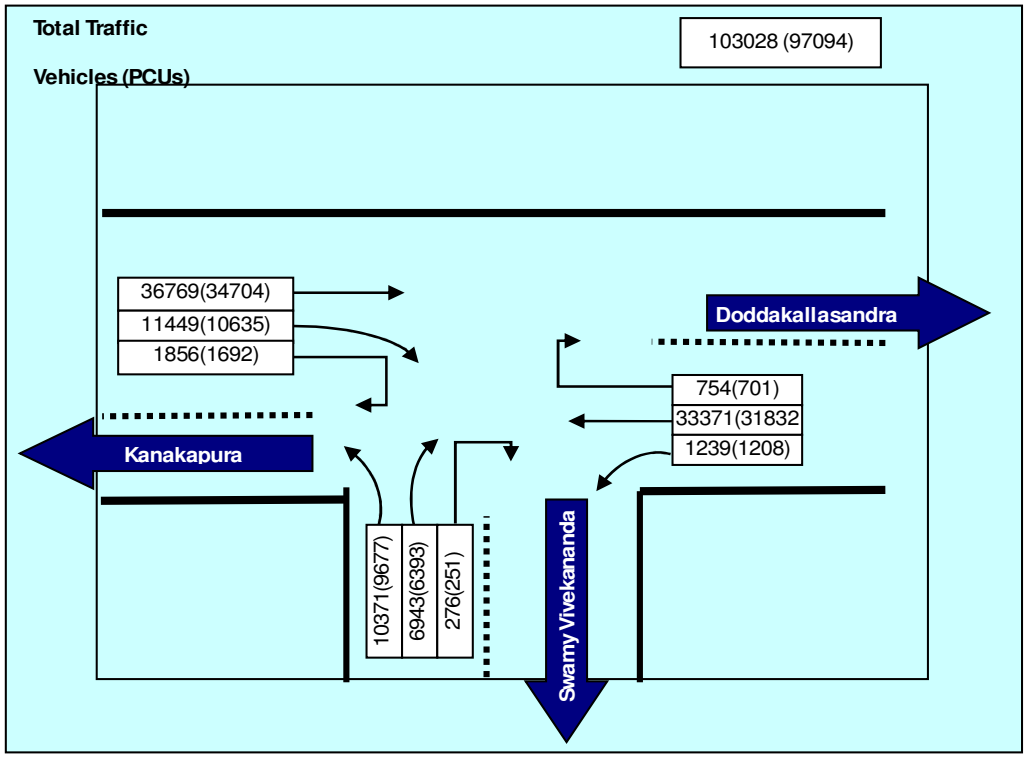

Figure 1.5 **Total Traffic at Adyar Aanand Bhavan Junction**

1.6.2 Justification/warrants for grade separators or interchanges

As per clause 5.10.4 of IRC: SP: 90-2010 and as per clause 4.5.6 of IRC: 92-2017, Grade Separators or Interchanges, in general, are expensive to construct and a major factor influencing the cost is the type of arrangement made for the various traffic movement. The arrangement may range from separating only one traffic movement from other to the complete separation of each traffic movement from every other movement, so that only merging and diverging movements remain. Similarly, the vehicle operating cost will vary depending on the type of ramp arrangement, from direct conflict-free connections to indirect connections involving extra travel distance. However, the following points may be helpful in guiding the choice of an interchange at the preliminary planning stage:

1. Interchanges will be required at all major crossings on highways developed to expressway standards.
2. An interchange may be justified at the crossing of a major arterial road with another road of similar category carrying heavy traffic.
3. An interchange may be justified when an at grade intersection fails to handle the volume of traffic resulting in serious congestion and frequent choking of the inter-section. This situation may arise when the total traffic of all the arms of the intersection is in excess of 10,000 PCU's per hour.
4. High and disproportionate rate of fatal and major accidents at an interaction not found to respond to other traffic control or improvement measure may warrant an interchange.
5. In some situations, the topography is such that interchanges are the only type that can be constructed economically.
6. The requirement of interchange may also be justified from the existing constraints of the junctions other than traffic volume like parking, market, important and religious structures, buildings with frequent crowding.
7. While planning interchange at a particular location the traffic requirements of the entire road on both sides should be taken into account.

The Adyar Aanand Bhavan Junction is a major junction formed by Kanakapura Road and Swamy Vivekananda Road. The present peak hour capacity of the junction is **6739 PCUs per Hour**. This junction exceeds **10,000 PCUs** per Hour in year **2031** which warrants for grade separation as per clause 5.10.4 of IRC: SP: 92-2010 and as per clause 4.5.6 of IRC: 92-2017.

Table 1.3 **Peak Hour traffic details for Adyar Aanand Bhavan Junction**

Peak Hour	Total	YEARS											
		2025	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
Morning	**Vehicles**	7539	8062	8622	9220	9860	10545	**11277**	12059	12896	13791	14749	15772
	PCUs	6739	7207	7707	8242	8814	9426	**10080**	10780	11528	12329	13184	14099
Evening	**Vehicles**	7523	8058	8632	9246	9904	10609	**11364**	12173	13039	13967	14962	16026
	PCUs	6910	7402	7929	8493	9098	9745	**10439**	11182	11977	12830	13743	14721

As per the above traffic data, the traffic at most junctions exceeded the capacity which warrants for grade separator facility or will exceed within the next 5 years and become bottleneck in near future. This indicates the requirement of alternative solutions to overcome this problem in terms of grade separators, development of alternative routes.

2.0 Estimated Traffic On Fly over

From the turning movement studies, through traffic on the fly over is calculated. It is to be noted, the major traffic on the fly over will be Cars and 2 wheelers. Estimated traffic is obtained for 2 conditions, i.e., with New Elevated road which is being planned from Marenahalli, Ragi Gudda to Kanakapura road crossing NICE corridor along BWSSB Pipe line road and Without Elevated corridor. The projection is presented in Table 2.1 and 2.2 respectively.

2.1 GROWTH RATE:

The traffic growth rates can be established for each category of commercial vehicles as per IRC 108-2015 and IRC 37-2018. However, the traffic growth of 5% is used for the traffic forecast for this project.As per Clause B.2.1.4 of IRC 108-2015 Normally, for a congested road (with high volume to capacity ratio) traffic growth is expected to be lower.

2.2 DESIGN TRAFFIC ESTIMATION

The traffic is forecasted for a period of 20 years. In the table, the year 2025 means the year from Jan 2025 to Dec 2025, i.e., Calendar year 2025. The construction period will be 1 years (2025-2026) and elevated corridor will be opened to traffic in the year 2026. The design service volume is calculated at each year. Also, the design service volume is compared with forecasted traffic data to obtain the year in which V/C ratio exceeds 1. These are given in the summary table at the end.

Projected Traffic in Nos From Kanakapura to Doddakallasandra																	Capacity	2700
Year	**2 Wheeler**	**Auto Rickshaw**	**Car/ Jeep/ Van**	**Mini Bus**	**Std. Bus**	**LCV**	**2 Axle**	**3 Axle**	**MAV**	**Tractor with Trailer**	**Tractor without Trailer**	**Cycle**	**Cycle Rickshaw**	**Bullock Cart**	**Horse**	**Sother (Special)**	**Total Nos**	**Total PCU.**	V/C
PCU	**0.75**	**1.2**	**1**	**1.4**	**2.2**	**1.4**	**2.2**	**2.2**	**2.2**	**4**	**1.4**	**0.4**	**1.5**	**1.5**	**1.5**	**2.2**			
2025	395	76	281	0	0	67	3	0	0	0	0	0	0	0	0	0	822	769	0.285
2026	424	79	302	0	0	71	3	0	0	0	0	0	0	0	0	0	880	822	0.304
2027	456	83	325	0	0	74	4	0	0	0	0	0	0	0	0	0	942	879	0.325
2028	490	87	349	0	0	78	4	0	0	0	0	0	0	0	0	0	1009	939	0.348
2029	527	92	375	0	0	82	4	0	0	0	0	0	0	0	0	0	1080	1004	0.372
2030	564	96	401	0	0	86	4	0	0	0	0	0	0	0	0	0	1152	1070	0.396
2031	604	101	429	0	0	90	4	0	0	0	0	0	0	0	0	0	1229	1140	0.422
2032	646	106	460	0	0	95	4	0	0	0	0	0	0	0	0	0	1311	1214	0.450
2033	691	112	492	0	0	100	5	0	0	0	0	0	0	0	0	0	1399	1294	0.479
2034	739	117	526	0	0	105	5	0	0	0	0	0	0	0	0	0	1492	1379	0.511
2035	788	123	560	0	0	110	5	0	0	0	0	0	0	0	0	0	1586	1464	0.542
2036	839	129	597	0	0	115	5	0	0	0	0	0	0	0	0	0	1685	1554	0.576
2037	893	136	635	0	0	121	6	0	0	0	0	0	0	0	0	0	1791	1650	0.611
2038	951	142	677	0	0	127	6	0	0	0	0	0	0	0	0	0	1904	1752	0.649
2039	1013	150	721	0	0	134	6	0	0	0	0	0	0	0	0	0	2023	1861	0.689
2040	1074	157	764	0	0	140	7	0	0	0	0	0	0	0	0	0	2142	1969	0.729
2041	1138	165	810	0	0	147	7	0	0	0	0	0	0	0	0	0	2267	2083	0.771
2042	1207	173	858	0	0	155	7	0	0	0	0	0	0	0	0	0	2400	2204	0.816
2043	1279	182	910	0	0	162	8	0	0	0	0	0	0	0	0	0	2541	2332	0.864
2044	1356	191	965	0	0	170	8	0	0	0	0	0	0	0	0	0	2690	2467	0.914
2045	1430	200	1018	0	0	179	8	0	0	0	0	0	0	0	0	0	2836	2600	0.963

2046	**1509**	**210**	**1074**	**0**	**0**	**188**	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2990**	**2741**	**1.015**
2047	1592	221	1133	0	0	197	9	0	0	0	0	0	0	0	0	0	3152	2889	1.070
2048	1680	232	1195	0	0	207	10	0	0	0	0	0	0	0	0	0	3324	3045	1.128
2049	1772	244	1261	0	0	218	10	0	0	0	0	0	0	0	0	0	3504	3209	1.189
2050	1861	256	1324	0	0	228	11	0	0	0	0	0	0	0	0	0	3679	3370	1.248

Projected Traffic in Nos FromDoddakallasandra to Kanakapura																	Capacity	2700
Year	2 Wheeler	Auto Rickshaw	Car/ Jeep/ Van	Mini Bus	Std. Bus	LCV	2 Axle	3 Axle	MAV	Tractor with Trailer	Tractor without Trailer	Cycle	Cycle Rickshaw	Bullock Cart	Horse	Sother (Special)	Total Nos	Total PCU.	V/C
PCU	0.75	1.2	1	1.4	2.2	1.4	2.2	2.2	2.2	4	1.4	0.4	1.5	1.5	1.5	2.2			
2025	634	76	319	0	0	55	0	0	0	2	0	0	0	0	0	0	1087	972	0.360
2026	682	80	343	0	1	58	0	0	0	2	0	0	0	0	0	0	1165	1041	0.385
2027	733	84	369	0	1	61	0	0	0	2	0	0	0	0	0	0	1249	1114	0.413
2028	788	88	396	0	1	64	0	0	0	2	0	0	0	0	0	0	1339	1193	0.442
2029	847	92	426	0	1	67	0	0	0	2	0	0	0	0	0	0	1436	1277	0.473
2030	906	97	456	0	1	70	0	0	0	3	0	0	0	0	0	0	1533	1362	0.505
2031	970	102	488	0	1	74	0	0	0	3	0	0	0	0	0	0	1637	1453	0.538
2032	1038	107	522	0	1	78	0	0	0	3	0	0	0	0	0	0	1748	1550	0.574
2033	1110	112	558	0	1	82	0	0	0	3	0	0	0	0	0	0	1866	1654	0.612
2034	1188	118	597	0	1	86	0	0	0	3	0	0	0	0	0	0	1993	1764	0.653
2035	1265	124	636	0	1	90	0	0	0	3	0	0	0	0	0	0	2119	1875	0.694
2036	1348	130	678	0	1	94	0	0	0	3	0	0	0	0	0	0	2254	1992	0.738
2037	1435	136	722	0	1	99	0	0	0	4	0	0	0	0	0	0	2397	2117	0.784
2038	1529	143	769	0	1	104	0	0	0	4	0	0	0	0	0	0	2549	2250	0.833
2039	1628	150	819	0	1	109	0	0	0	4	0	0	0	0	0	0	2711	2391	0.886
2040	1726	158	868	0	1	115	0	0	0	4	0	0	0	0	0	0	2871	2531	0.937
2041	1829	166	920	0	1	120	0	0	0	4	0	0	0	0	0	0	3041	2679	0.992
2042	**1939**	**174**	**975**	**0**	**1**	**127**	**0**	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**3220**	**2836**	**1.050**
2043	2055	183	1033	0	1	133	0	0	0	5	0	0	0	0	0	0	3410	3002	1.112
2044	2179	192	1095	0	1	139	0	0	0	5	0	0	0	0	0	0	3612	3178	1.177
2045	2298	202	1156	0	1	146	0	0	0	5	0	0	0	0	0	0	3809	3351	1.241

2046	2425	212	1219	0	1	154	0	0	0	6	0	0	0	0	0	0	4016	3532	1.308
2047	2558	222	1286	0	1	161	0	0	0	6	0	0	0	0	0	0	4236	3724	1.379
2048	2699	233	1357	0	1	170	0	0	0	6	0	0	0	0	0	0	4467	3926	1.454
2049	2847	245	1432	0	2	178	0	0	0	6	0	0	0	0	0	0	4710	4140	1.533
2050	2990	257	1503	0	2	187	0	0	0	7	0	0	0	0	0	0	4946	4347	1.610
2051	3139	270	1579	0	2	196	0	0	0	7	0	0	0	0	0	0	5193	4564	1.690
2052	3296	284	1657	0	2	206	0	0	0	7	0	0	0	0	0	0	5453	4792	1.775
2053	3461	298	1740	0	2	216	0	0	0	8	0	0	0	0	0	0	5725	5032	1.864
2054	3634	313	1827	0	2	227	0	0	0	8	0	0	0	0	0	0	6011	5283	1.957
2055	3816	328	1919	0	2	239	0	0	0	9	0	0	0	0	0	0	6312	5548	2.055

3.0 CONCLUSION

1. The turning movement results obtained for junctions on Kanakapura road show that the capacity of the junctions will be exceeded the design capacity of junction (10000 PCUs per Hour) very shortly which requires immediate intervention to avoid bottlenecks or congestion at the junctions.

2. This can be done either by making changes to policy (modal shifts and promoting use of public transport) or by construction of grade separators at each junction.

4. As per Site condition, 4 lane fly over with single pier along the median is not viable, as the existing BMRCL Green line is operational, which is at the median.

Hence it is proposed for 2 Lane flyovers in each direction integrating 2 junctions with 7.5m carriageway in each direction

APPENDIX - 2- Geotechnical Investigation Report

ISO No.	QMP 8.2.4 R/A
Report No.	GECPL/260625-228/R

GEOTECHNICAL INVESTIGATION REPORT FOR THE PROPOSED ELEVATED CORRIDOR (FLYOVER) AT ADYAR ANANDA BHAVAN RAGHUVANAHALLI CROSS, KANAKAPURA ROAD

CLIENT

The Director (Technical),

Bengaluru Smart Infrastructure Limited (B-Smile),

N.R. Square, Bangalore – 560 002

CONSULTANT

M/s. Nagesh Consultants,

 # 2, 6th Cross, Ashokanagar,

BSK 1st Stage, Bangalore – 560 050

GEO-ENGINEERING COMPANY PVT. LTD.

#28, 5th Main, 3rd Phase, Peenya Industrial Area, Behind Bescom,

Bengaluru - 560 058

Report on	:	Geotechnical Investigation Report for the Proposed Elevated Corridor (Flyover) at Adyar Ananda Bhavan Raghuvanahalli cross, Kanakapura Road
Report No	:	GECPL/260825-228/R
Report for	:	The Director (Technical), Bengaluru Smart Infrastructure Limited (B-Smile), N.R. Square, Bangalore – 560 002
Reference	:	Telephonic Confirmation
Managing Director	:	Dr. Jayaprakash K N
Technical Advisor & Reported by	:	Mr. Nagesh C Technical Manager (Geo-Technical Engg)
Field investigation carried out by	:	Mr. Nandish Kumar & Team Site Engineer's
Date of submission of report	:	01.08.2025

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LIST OF ANNEXURES

List of Annexure	Description
Annexure I -	Bore Hole Location
Annexure II -	Field Records and Bore Logs
Annexure III -	Laboratory Testing
Annexure IV-	Grain Size Distribution Curves

1.0 INTRODUCTION

M/s. Nagesh Consultants on behalf of The Director (Technical), Bengaluru Smart Infrastructure Limited (B-Smile), Bengaluru had entrusted us to carry Geotechnical investigation for the proposed Elevated Corridor project near Kanakapura Road, Bengaluru. The primary objective of this investigation is to establish the geotechnical condition at the site and to evaluate the allowable bearing pressure and other engineering design parameters through the various field and laboratory tests. This report consists of the details about the field and laboratory tests performed and the recommendations made based on the test results.

2.0 SCOPE

Field work comprising of drilling of twenty five boreholes conducting SPT tests, collection of samples started on 26.06.2025 and was completed on 17.07.2025. The primary objective of this investigation was to obtain information about the sub-surface conditions at the site and obtain net allowable bearing pressure for design of foundations. Fig A: shows the location of boreholes for the proposed construction site ***(Refer Annexure I)***.Borehole details are summarized below:

BH No.	Depth of explorations (m)	Ground Water Table, (m)
BH-1	16.5	Nil
BH-2	16.5	Nil

3.0 FIELD INVESTIGATION- RELEVANT DESCRIPTION

3.1 Boring and Drilling

The field investigation comprised of advancing 150mm boreholes using rotary drilling rig with bentonite mud circulation. Standard penetration test (SPT) was conducted at every 1.50m intervals as per IS: 2131. The number of blows for 30cm penetration of split spoon sampler was recorded as N-values. The boreholes were terminated after drilling to their respective depth. The various sub-surface strata are presented in the respective bore charts.

3.2 Standard Penetration Test (SPT) in boreholes

Standard Penetration Test (SPT) to determine penetration resistance was conducted in the boreholes using the procedure described in IS: 2131. In this method, driving bit is replaced by split spoon sampler (50.8 mm OD and 35 mm ID) and the sampler is driven by dropping 63.5 kg hammer on the top of the driving collar with a free fall of 75 cm. The length of the sampler is 60 cm. The sampler is first driven through 15 cm as "Seating Drive". It is further driven through 30 cm. The number of blows required to drive the sampler for 30 cm beyond seating drive is termed as "Penetration Resistance, N". Representative samples were collected using split spoon sampler. Where full 30cm penetration beyond seating drive was not possible, number of blows and corresponding penetration is mentioned in bore logs. ***Refer Annexure II for Bore logs.***

3.3 Sampling in boreholes

In soil/completely weathered rock, representative samples were mainly collected from split spoon sampler used for conducting SPT at close intervals of 1.5m up to end of respective strata. Soil formation is usually drilled by soil cutter and weathered rock formations are usually drilled by tungsten carbide core bits.

3.4 Sampling in rock formations

In boreholes where rock cores could be recovered, same was logged, placed sequentially in good quality wooden core boxes. Individual core piece lengths were measured and core recovery and Rock quality designation computed as under.

Rock core recovery {CR % = (Length of Core / Length of run) x 100}

Rock quality designation (RQD) = (Total length of core pieces of >100mm / length of run) x 100}. Same is reflected in respective bore logs.

3.5 Ground water table

At time of investigations, subsequent to completion of borehole and after allowing water level to stabilize for minimum 24 hours, water table/Seepage water was not encountered at any depth below natural ground level during the time of investigation; however, a point to be noted is that, water levels are invariably subjected to seasonal fluctuations.

4.0 LABORATORY TESTS ON SAMPLES

Assessment of Geotechnical Properties - Samples from Boreholes

The following Tests were carried out

- Grain size analysis
- Natural Moisture content
- Atterberg's Limits
- UCS test on Rock Sample

Test results are as shown in Annexure III

5.0 SUB - SOIL PROFILE ANALYSIS

5.1 Nature of Soil Stratification

Based on detailed analysis, the soil conditions described is summarized for the entire project site as under

Layer I: Soil Overburden

The sub-soil stratification essentially comprises of sandy Silt/ silty formations with layer thickness of 0.5 – 6.0m.

Layer II: Completely weathered rock (Soft Disintegrated rock)

Occurs below layer I and comprises of 'very dense' complete to highly weathered rock (SPT 'N' values consistently N >100 and Nil core recovery). In 'in-situ' conditions, stratum is considered 'very dense/stiff' /incompressible with very good bearing characteristics. In this layer sample recovery was limited and sufficient for visual classification only.

Layer III- Rock formations

Rock is seen in all the bore holes. Based on the core recovery and rock Quality Designation rock may classified as Soft Rock/Moderately Weathered Rock/Fractured rock formations given below.

5.2 Sub-Soil stratification Description:

BH No.	Explored Depth, m	Thickness of layer in sequence (m)			
		Layer – I Soil	Layer – II CWR(N>100)	Layer III- Rock Formations	Remarks
BH-1	16.5	0.0 to 3.0	3.0 to 12.0	12.0 to 16.5	FR
BH-2	16.5	0.0 to 6.0	6.0 to 16.5	--	--

SR- Soft Rock, MWR- Medium weathered rock, HR- Hard Rock, CWR- Completely Weathered Rock,

6.0 RECOMMENDATIONS FOR DESIGN OF FOUNDATIONS

6.1 Inferences drawn from borehole investigations

Heavy load transfer is anticipated from the Bridge structure envisaged. Hence deep foundations such as Bored Cast-in-situ Piles may be recommended. Pile diameter has been considered as 1.2m and 1.35m. Piles should be socketed 7 **times the Pile diameter in dense weathered rock /refusal strata (N>100) layer (or) (or) 2 times the pile diameter in to hard rock (CR>30%) whichever is met earlier.**

Reference	Pile diameter, D (m)	*Depth of pile, m	Safe axial load (tons)	Uplift Capacity, Tons	Lateral load (tons) (fixed head condition)	Depth of fixity, m
I	II	III	IV	V	VI	VII
BH-1 to 4	1.2	17.0	500	300	100	8.0
	1.35	18.0	700	400	100	8.0

CONCLUDING REMARKS

This Geotechnical report is valid for site conditions that prevailed at time of subsurface explorations. Geo-technical design recommendations are based on the data derived from borehole investigations. There is a possibility that strata variations could occur. If any variations indicate significant deviations from the findings of this report, same shall be brought to the notice of Geo-technical consultant for appropriate design review.

For GEOENGINEERING COMPANY PRIVATE LTD

(Dr. JAYAPRAKASH K N)

ANNEXURE I

LOCATION OF BORE HOLES

ANNEXURE II

Client	The Director (Technical), B-Smile	**BOREHOLE - 01**	**Size of Borehole**	150mm
Job No	228		**Ground Water Table**	Nil
Project	Elevaated Corridor		**Commenced**	11-07-25
Location	On kanakapura Road		**Completed**	11-07-25

Description of Sub-soil stratum	**Depth (m)**	**Legend**	**Sample**	**SPT TEST, number of blows recorded**			**N Value = N_2+N_3**	**Core Recovery, %**	**RQD, %**	**Remarks**
				1st 15cm	**2nd15cm**	**3rd15cm**				
				N_1	**N_2**	**N_3**				
Reddish sandy Silt	0.0 0.5 1.5									
Whitish gray CWR	3.0		WS	25B/0cm	R		>100			
Grayish to whitish yellow CWR	4.5		WS	R			>100			
	6.0		WS	R			>100			
	7.5		WS	R			>100			
	9.0		WS	R			>100			
	10.5		WS	R			>100			
	12.0		WS	R			>100			
Whitish to grayish black fractuired rock	13.5 16.5		CR CR					18 18	Nil Nil	

SPT=Standard Penetration test	Refusal means SPT N>50	B= No. of blows	R=Rebound	SR: Soft Rock
HR:Hard Rock	DS=Disturbed Sample	CWR: completely weathered rock		SDR: Soft Disintegrated Rock

Bore hole was terminated at 16.5m depth below existing ground level

Client	The Director (Technical), B-Smile	**BOREHOLE - 2**	**Size of Borehole**	150mm
Job No	228		**Ground Water Table**	Nil
Project	Elevaated Corridor		**Commenced**	12-07-25
Location	on kanakapura Road		**Completed**	12-07-25

Description of Sub-soil stratum	**Depth (m)**	**Legend**	**Sample**	**SPT TEST, number of blows recorded**			**N Value = N_2+N_3**	**Core Recovery, %**	**RQD, %**	**Remarks**
				1st 15cm	**2nd15cm**	**3rd15cm**				
				N_1	**N_2**	**N_3**				
Filled up	0.0 0.5									
Whitish yellow to grayish brown sandy Silt	1.5		SPT	4	5	7	12			
	3.0		SPT	7	9	11	20			
Whitish to grayish yellow sandy Silt	4.5		SPT	15	18	22	40			
Whitish to yellowish gray CWR	6.0		SPT	55B/10cm	R		>100			**Refusal Starata**
	7.5		WS	25B/0cm	R		>100			
	9.0		WS	R			>100			
	10.5		WS	R			>100			
	12.0		WS	R			>100			
	13.5		WS	R			>100			
	15.0		WS	R			>100			
	16.5		WS	R			>100			

SPT=Standard Penetration test	Refusal means SPT N>50	B= No. of blows	R=Rebound	SR: Soft Rock
HR:Hard Rock	DS=Disturbed Sample	CWR: completely weathered rock		SDR: Soft Disintegrated Rock

Bore hole was terminated at 16.5m depth below existing ground level

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ANNEXURE III

LABORATORY TEST REPORT ON SOIL SAMPLES

Client	The Director (Technical), B-Smile	**Project**	Elevated Corridor	**Job No.**	220
Location	om Kanakapura Road	**Date of Sample Recived**	12-07-25	**Date of Test**	13-07-25

BH No.	Sample Type	Sample no.	Depth (m)	Grain Size Distribution (%)					Atterberg Limits (%)			Free Swell Index (%)	IS Classification (IS:1498-1970)	Natural Moisture Content (%)	Bulk Density (gm/cc)*	Specific Gravity*	Shear Parameters	
				Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt & Clay	Liquid Limit	Plastic Limit	Plasticity Index						Cohesion (kN/m^2)	Angle of Internal Friction (deg.)
BH-01	SPT	228/40	3.0	32.2	17.6	16.5	28.6	5.1	--	--	--	--	--	2.4	--	--	--	--
	SPT	228/41	4.5	1.5	16.2	67.8	12.9	1.6	--	--	--	--	--	14.8	--	--	--	--
	SPT	228/42	6.0	1.9	11.5	69.3	16.3	1.0	--	--	--	--	--	16.2	--	--	--	--
	SPT	228/43	9.0	2.2	26.9	66.1	4.0	0.8	28.9	--	NP	--	SM	14.4	--	--	--	--
	SPT	228/44	10.5	0.2	17.6	75.8	5.0	1.4	--	--	--	--	--	13.1	--	--	--	--
	SPT	228/45	12.0	0.2	14.3	72.4	12.1	1.0	--	--	--	--	--	13.4	--	--	--	--
BH-2	SPT	228/46	1.5	2.4	4.4	13.0	19.2	61.0	--	--	--	--	--	25.2	--	--	--	--
	SPT	228/47	3.0	0.1	1.4	13.5	18.7	66.3	50.00	22.5	27.5	--	CI	28.3	--	--	--	--
	SPT	228/48	4.5	0.0	1.6	9.5	27.1	61.8	--	--	--	--	--	35.4	--	--	--	--
	SPT	228/49	6.0	0.0	2.1	13.7	32.7	51.5	--	--	--	--	--	33.0	--	--	--	--
	SPT	228/50	9.0	0.4	12.9	58.7	23.8	4.2	--	--	--	--	--	18.9	--	--	--	--
	SPT	228/51	12.0	0.3	2.7	61.3	30.2	5.5	--	--	--	--	--	22.1	--	--	--	--
	SPT	228/52	13.5	1.3	3.1	64.3	27.3	4.0	--	--	--	--	--	22.7	--	--	--	--

Authorised Signatory

Abrreviations used: UDS: Undisturbed Sample, DS: Disturbed Sample, SPT: Standard Penetration Test, BH: Bore Hole, NP: Non Plastic

Test Method Referred to:	Grain Size Distribution: IS 2720-4 1985 RA 2015	Liquid and Plastic Limit: IS 2720-5 1985 RA 2015	Specific Gravity: IS 2720-3 SECTION 1 & 2 1980 RA 2011
	Direct Shear Test: IS 2720-13 1986 RA 2015	Free Swell Index: IS 2720-40 1977 RA 2011	Natural Moisture Content: IS 2720-2 1973 RA 2015
Test Method Variation :	None		

END OF TEST RESULTS

ANNEXURE IV

GRAIN SIZE ANALYSIS CURVES

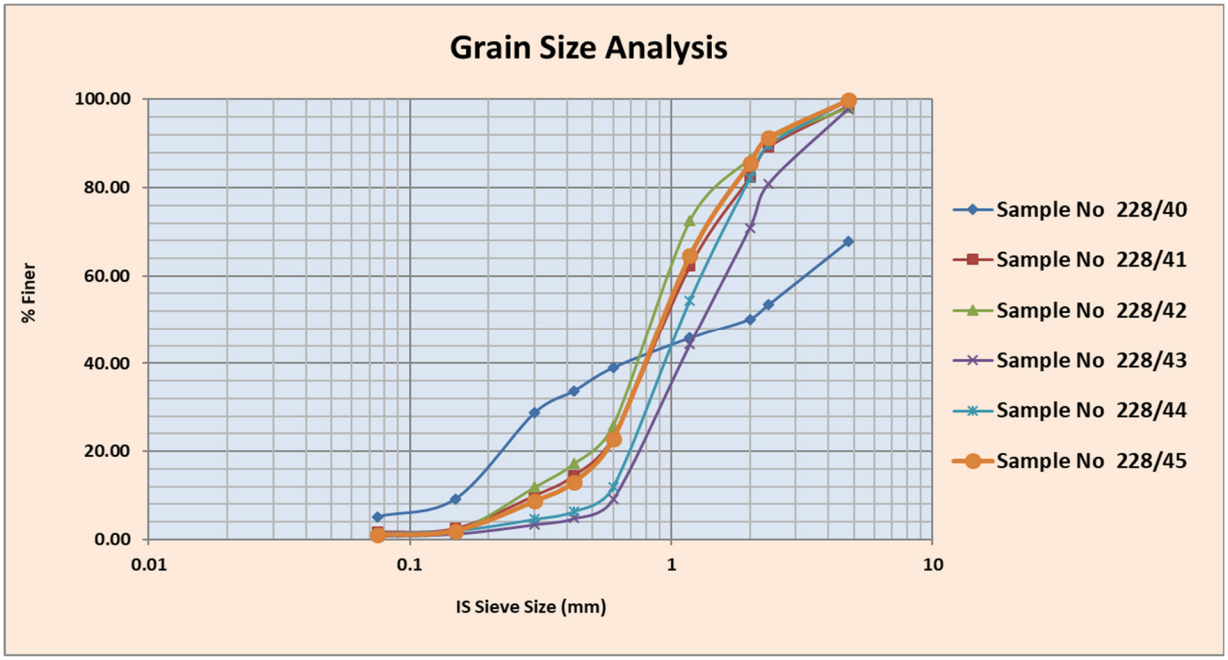

Fig. No. 1: Grain size analysis Curves around BH-01

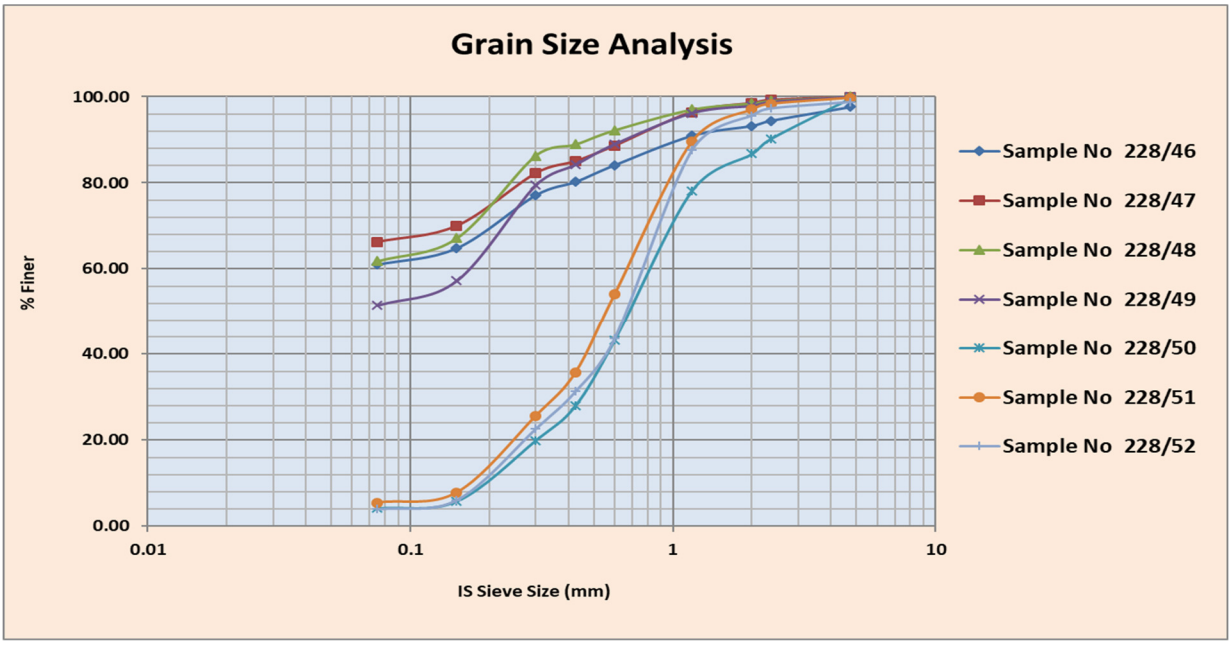

Fig. No. 2: Grain size analysis Curves around BH-02

***** END OF REPORTS*****